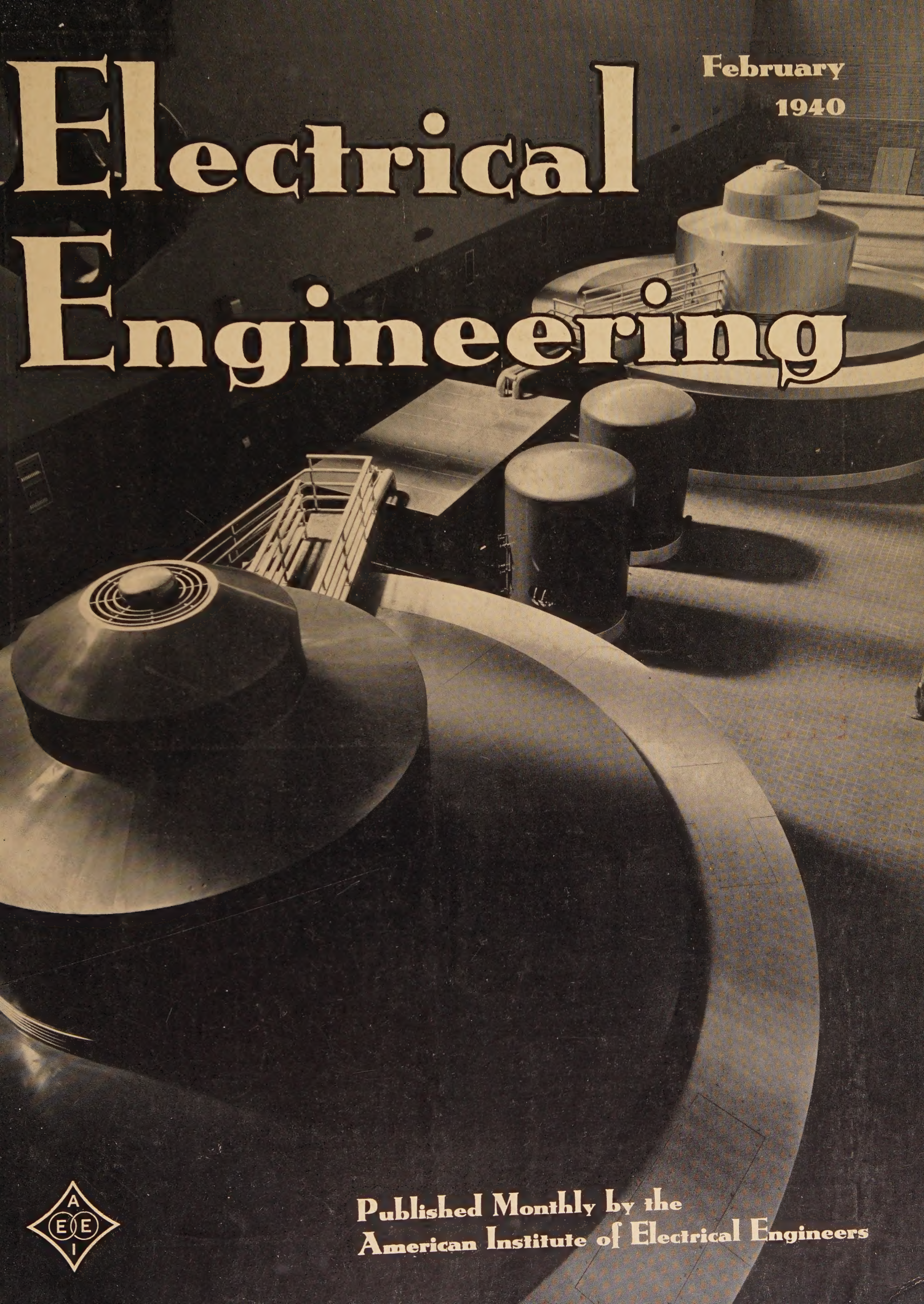
# Electrical Engineering

February
1940



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● When a bushing fails electrically—either from puncture or from progressive surface breakdown of the internal insulation—you can count on a sizable bill for repairing or replacing the unit. Such failures and their attendant costs can be avoided, however, by using O-B bushings which have internal barriers of porcelain. This insulation, which always remains stable, is not affected in any manner by moisture, temperature, current leakage, or electrical stress. And there you have the big reason for the trouble-freeness and long life of O-B bushings—the absence of change in the characteristics of porcelain!

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# Electrical Engineering

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## for February 1940—

**The Cover:** The two 36,000-kw main generating units in the Pickwick Landing plant of the Tennessee Valley Authority. According to an article in this issue (pages 59–62) the electrochemical industry is the only one able to utilize the large amounts of power being made available at such Federal projects.



## *Transactions Section* *(Follows EE page 92; a preprint of pages 65–128 of the 1940 volume)*



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F. MALCOLM FARMER, President H. H. HENLINE, National Secretary



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# High Lights • •

**Electricity in Chemical Plants.** Many chemical plants, which are among the largest industrial users of electric power, find electricity essential for obtaining the high temperatures required in their processes; in plants where the relatively low temperatures required may be obtained from steam, there are many opportunities for the production of inexpensive power for driving equipment, illumination, and other uses from combined steam and electric generating plants. Special precautions must be observed in selecting equipment because of the fire or corrosion hazards in most chemical plants (*pages 77–83*).

**Steel Mills.** The decline in production of heavy rolled steel products, such as rails and plates for railroads, structural shapes and plates for the building industry, and large welded and seamless pipe, during the past decade has been paralleled by a rise in production of light flat-rolled products for the automotive, container, and other industries. This shift in requirements, together with revolutionary developments in manufacturing equipment and processes, has resulted in the installation of many new strip mills and associated equipment (*pages 70–7*).

**Nuclear Disintegration.** Outstanding research accomplishment of 1939 in physics and chemistry is recognized to be the discovery that enormous amounts of atomic energy can be released by the fission of uranium nuclei when bombarded with neutrons. The significance of this achievement was discussed at the recent AIEE winter convention by 1938 Nobel Prize Winner Enrico Fermi, who indicated that results of far-reaching significance may be expected from further experiments (*pages 57–8*).

**News Section Rearrangement.** Beginning with this issue, the material in the news section of Electrical Engineering has been divided for the convenience of the reader into two main sections, one containing news of Institute activities, and the other items of interest about the electrical industry, engineering education, other societies, and related matters. Key subject headings within the divisions serve as further guides to the reader. Members are invited to comment on the change (*pages 84-92*).

**Science in the Electrical Industry.** The story of the electrical industry is one of growth in giant breath-taking strides and great technical advances. Behind this growth, the rate of which has shown no diminution since the birth of the industry, lies a significant, important fact, says an executive of one of the leading electrical manufacturing companies: "The industry has consistently accepted and adapted to its own use the new ideas and developments of science" (*pages 63–7*).

**Telegraph Switching.** A telegraph relay office must be provided with means for storing the incoming signals without delaying their reception, for moving them immediately from the incoming to the outgoing circuit terminals, and for retransmitting them as soon as the outgoing circuit is clear; the latest switching system requires only one-quarter of the time of manual operation (*Transactions pages 71–8*).

**Progress in Machinery.** Between 1934 and 1939, substantial progress was made in various branches of the art in electrical machinery; outstanding items are turbine generators of large ratings operating at 3,600 rpm, and the application of hydrogen cooling; use of glass insulation; and sealed-off mercury-arc rectifiers (*Transactions pages 103–06*).

**Use of Federal Water Power.** Large quantities of electric power are becoming available at the extensive Federal irrigation and hydroelectric projects. The electrochemical industry is said to be the only one that can absorb this power. Suitable raw materials for various electrochemical processes are available at or near all of the new power sites (*pages 59–62*).

**Capacitor Timing.** A capacitor and resistor in series may be used as a timing device that has already been applied widely for resistance-welding control, and which now is extended to motor control; the availability of large capacitors eliminates the need for amplifiers (*Transactions pages 65–70*).

**Potential Devices.** New theoretical methods, introducing an equivalent circuit, have been devised for the analysis of the transient and steady-state performance of potential devices of the capacitor type; field, laboratory, and network-calculator tests have been made for verification (*Transactions pages 91–102*).

**Electricity and Petroleum.** Design and operation of oil refineries have been affected by improvements in electrical apparatus, as electric power is combined with steam in order to obtain the greatest possible economy; explosive and corrosive gases have required special consideration (*Transactions pages 106–10*).

**Illumination Modernization.** By installing luminaires of a newly developed design, the illumination level in a drafting room of a large eastern power company was increased 150 per cent over that obtained with the replaced system, with an increase in power consumption of less than 60 per cent (*pages 68–9*).

**Watt-Hour Meters.** A peculiar state of vibration has been found to exist in the moving system of an a-c watt-hour meter when only the potential element is excited, which has been found by experiment to result in a total travel of the meter pivot approximately ten times as great as the travel at full load (*Transactions pages 116–22*).

**Oilless Circuit Breaker.** Using water in place of oil, circuit breakers for 15 kv have operated satisfactorily in service at a rating of 500,000 kva, and development has been carried to a rating of 1,500,000 kva. Outstanding advantage is the noninflammability of the interrupting medium (*Transactions pages 111–16*).

**Breakdown in Oil.** Knowledge of the breakdown of gaps submerged in oil and subjected to surge voltages is desirable for circuit-breaker design, and some now has been obtained by use of a specially constructed test barrel (*Transactions pages 78–84*).

**Transformation Theory.** Equations for general static polyphase networks may be obtained from the canonical equations of a general linear bilateral network with a minimum of algebraic work by the application of transformation matrices (*Transactions pages 123–8*).

**Ground Protection.** If radial distribution feeders are to be cleared when a ground fault occurs, a sensitive protective means is necessary because contact conditions at the fault may permit only a small current to flow (*Transactions pages 84–90*).

**Coming Soon.** Among specia larticles and technical papers now undergoing preparation for early publication are: an article on distribution systems in buildings, by L. W. Moxey, 3rd (A'30); an article on the status and trends of engineering education in the United States today, by Dugald C. Jackson (A'87, F'12); an article presenting a summary of bridge networks, by Walter J. Seeley (A'19, M'28); a paper describing a new type of d-c to a-c vibrator inverter, by O. Kiltie (A'31); a paper describing a new technique for lead cable sheathing, by B. B. Reinitz and R. J. Wiseman (F'27); a paper on radio - frequency high - voltage phenomena, by Andrew Alford and Sidney Pickles (A'37); a paper on instruments and methods of measuring radio noise, by C. V. Aggers (A'39), Dudley E. Foster, and C. S. Young; and a paper describing a direct-acting generator voltage regulator, by W. K. Boice (A'39), S. B. Crary (M'37), Gabriel Kron (A'30), and L. W. Thompson (A'39).

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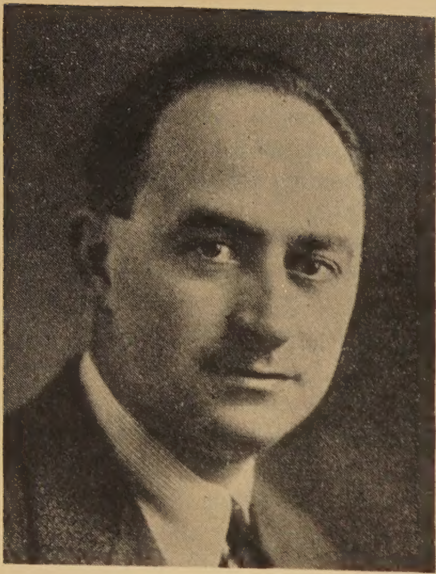

# Nuclear Disintegrations

ENRICO FERMI

**The fission of uranium, in which the uranium nucleus splits into two fragments of comparable size, achieved during 1939 by bombardment of uranium with neutrons, has stimulated great activity in this field of research and may lead to further research of fundamental and far-reaching importance.**

MUCH of the information available at present on the structure of atomic nuclei has been gathered by a successful application of the technique of the so-called nuclear bombardments. This technique, initiated about 20 years ago by Lord Rutherford, consists in hurling against the nucleus a projectile (originally this was one of the alpha particles spontaneously emitted by radioactive substances) and in observing the changes in the nuclear structure produced by the impact. In the last years this technique has received new impetus due, on one hand, to the development of artificial sources of high-energy projectiles (high-voltage apparatuses and cyclotrons) and, on the other hand, to the discovery of the neutron.

Several hundreds of different artificial nuclear disintegrations have now been investigated. Their study has led to the development of the so-called nuclear chemistry in which, instead of changes of aggregations of atoms to form different molecules, as in chemistry, changes in the aggregation of neutrons and protons to form different nuclei are observed. This nuclear chemistry obeys rather simple rules, and the different types of nuclear reactions can be summarized as in the following paragraphs.

Nuclei have been bombarded so far mostly with the following types of projectiles: alpha particles, protons, deuterons, and neutrons. Whenever one of these particles strikes the nucleus it is incorporated into the nuclear structure, and another particle may be emitted which belongs to one of the same four types. In a few instances nuclear reactions have been produced by hard gamma rays or by high-energy electrons. We have further to add the many cases of radioactivity, both natural and artificial, in which an unstable nucleus spontaneously emits an alpha particle, or an electron (negative or positive). The residual nucleus that remains after the reaction is always different from the one before the impact. In general, however, the changes in atomic weight, or atomic number, are not very large. Indeed, the greatest changes in atomic number occur when an alpha particle is either absorbed or emitted in the process. Since the electric charge of the alpha particle is of two units, this produces a displacement in the atomic number of two places only.

In many cases in which a chemical identification of the reaction products of nuclear bombardment has been possible, it has been found consistently that the reaction products are either isotopes of the original element bombarded, or they differ from it in atomic number by only a few units. There was, therefore, a great sensation among nuclear physicists last year when Hahn and Strassman announced that by bombardment of uranium (atomic number 92) with neutrons, they had found definite evidence of the formation of some radioactive isotopes of barium (atomic number 56). Such a change by 36 units in the atomic number had never been considered possible before; subsequent investigation has shown that it corresponds to a nuclear reaction of an entirely new kind, in which the uranium nucleus splits into two fragments of comparable size.

This discovery of Hahn and Strassman has opened a very interesting new field of investigation. It is well known that all the heaviest elements of the periodic system are to some extent unstable, as is shown by their natural radioactivity. The physical reason for this instability is the electrostatic repulsion between the positively charged constituents of the nucleus. These repulsions are approximately proportional to the square of the nuclear charge and, therefore, increase considerably with increasing atomic number. Instability sets in when the electrostatic destructive forces overcome what we may call the cohesive forces of the nucleus.

The theory of nuclear forces is not yet developed so far as to enable us to calculate exactly at what value of atomic number instability sets in. Probably, however, this limit is not far beyond 92, the atomic number of uranium. The discovery of Hahn and Strassman shows, indeed, that in the case of uranium the relatively unimportant perturbation of the nuclear structure due to the capture of a neutron is already sometimes sufficient for breaking into pieces the nucleus, giving rise to the so-called fission process.

A pictorial image of the process has been suggested by Bohr, who compared this process with what happens when a liquid drop divides into two smaller droplets as a consequence of a very strong oscillation in which it changes

Essential substance of an address delivered at a special session of the AIEE 1940 winter convention, January 24.

ENRICO FERMI, distinguished physicist and winner of the 1938 Nobel Prize in physics, is now associated with the department of physics, Columbia University, New York, N. Y., where he is engaged, with others, in research on nuclear physics.

from the original spherical form into an elongated shape. In the case of uranium, however, as soon as the two fragments are separated and the cohesive forces cease to attract them, the strong repulsion due to both fragments being positively charged, pushes them apart, impressing on them a relatively enormous kinetic energy. In fact, the amount of energy released in the fission process is approximately ten times greater than any amount of energy released in atomic disintegrations, it being of the order of 200 million electron volts. (An electron volt is defined as the amount of energy gained by an electron in passing from a point of low potential to a point one volt higher in potential.) Although the discovery of this process is only one year old, a great many investigations have been carried out in laboratories all over the world, so that a general description of the main features of the phenomenon is now possible, in which, however, many important details are still missing.

The fission process can be produced by bombardment with fast neutrons having energy above one million electron volts, and by slow neutrons, having energy corresponding to thermal agitation equivalent to a small fraction of an electron volt. Neutrons of intermediate energy are rather inefficient as agents for producing fission. It has been pointed out, especially by Bohr, that this fact might possibly be interpreted on the assumption that the fast-neutron and the slow-neutron process are due to two different isotopes of uranium. Probably the fast-neutron process is due to isotope 238, which represents more than 99 per cent of natural uranium, whereas the slow-neutron process might be attributed to a much rarer isotope of weight 235, which is known to be present in an amount somewhat less than 1 per cent and is the parent substance of the actinium radioactive family. No direct experimental information on this point, which is of considerable importance both from the theoretical and the practical point of view, is at present available.

Each fragment into which uranium splits in the fission process weighs approximately one-half of the original nucleus. Apparently, however, the fission does not always occur in exactly the same way, and there are certain limits between which the weight of the fragments can vary. Since each fragment gives rise to several artificially radioactive nuclei, it is clear that the fission process will produce a large variety of new radioactive elements. An extensive chemical investigation of these elements has been carried out in several laboratories and has already led to the identification of more than 20 such elements, but the list is probably still far from being complete.

When uranium undergoes fission some neutrons are emitted. It has not been decided so far whether these neutrons are emitted in the very act of fission, or a very short time after the process. The two fragments into which uranium splits get away with a very high internal excitation. The excitation energy might be so large as to produce the spontaneous emission of neutrons from the two fragments. The largest part of this emission of neutrons certainly occurs within an exceedingly short time after the fission; the emission of a small number of neutrons, however, lasts for some seconds after the fission process. This delayed emission of neutrons is probably a secondary process of some beta disintegration.

The emission of neutrons is not only an interesting feature of the phenomenon, but might perhaps be of far-reaching importance, as it opens at least one possibility of exploiting the fission of uranium for the production of nuclear reactions on a large scale.

Let us assume for a moment that in every fission process two neutrons are emitted (actually experiment shows that probably the average number of neutrons emitted is somewhat larger, between two and three). If this were so every neutron that enters the uranium nucleus and produces fission would give rise to two neutrons with the net gain of one. If we assume that these two neutrons again produce each one a fission we get at the end four neutrons from the original one. Any one of these four neutrons might again produce a fission, multiplying the number of neutrons once more by two, and so forth, until the number of neutrons might in principle be multiplied by an arbitrarily large factor, thus giving rise to a self-perpetuating nuclear reaction—the so-called chain reaction. In order that the chain reaction might occur, it is obviously necessary not only to have more than one neutron produced for every neutron that is absorbed in the process of fission, but also to be able to utilize for producing new fissions a large faction of the neutrons produced; otherwise the loss might be larger than the gain.

Assuming, as before, that two neutrons are produced in every fission, it is evident that for the chain reaction to take place more than one-half of the neutrons produced must be used in new fission processes. There is now, on one hand, some loss of neutrons that diffuse outside of the reacting mass before they have a chance to react. This loss can be made, at least in principle, arbitrarily small, by increasing the amount of the reacting material. On the other hand, some of the neutrons are lost for the reaction because they are absorbed by uranium itself in a second process, which does not lead to fission but to the formation of a heavy radioactive isotope of uranium. Some absorption is finally due to those substances that must be present in order to slow down the neutrons, so as to increase their aptitude to react with uranium. Whether these absorptions are, or are not, sufficiently large to prevent the chain reaction, cannot be answered at present. The experiments require the use of very large amounts of both uranium and "slowing-down" materials and are, therefore, very expensive. The problem seems to me, however, worth the effort that its solution will cost. There is indeed a chance that research on these lines might open entirely new technical opportunities, whose range at present can only be guessed. The large release of energy by the reaction, whose development, by the way, could be easily controlled by simple mechanical devices, is indeed probably only one and very likely not the most important aspect of the problem. Far more important might eventually prove the production of radioactive materials and of neutrons in practically unlimited amounts, for medical, biological, and physical investigations. In conclusion, although there is only a chance of success, the stake appears large enough to justify some gambling.

# Federal Water Power and Electrochemical Industries

COLIN G. FINK

**The electrochemical industry is said to be the only one that can absorb the large quantities of electric energy soon to become available from the many Federal irrigation and hydroelectric projects. As suitable raw materials for various processes are available at or near all of the new power sites, the construction of one or more electrochemical plants at each of the new centers has been advocated, which will result in an increasing demand for engineers conversant in both electrical and chemical engineering. Young engineers now obtaining their training are urged to fit themselves to take advantage of these opportunities.**

AN INTERESTING situation has arisen in consequence of the extensive Federal dam projects that have been under way for some years. Basically the Boulder, Bonneville, Grand Coulee, Norris, and other dams were developed for other purposes, electric power being "merely" a by-product. The problem that is of special interest to engineers, in particular to electrical and chemical engineers, is what is to become of the large quantities of power remaining after all requirements for domestic uses, lighting, and mechanical power have been amply provided for. This question has been carefully and thoroughly discussed by experts in both the power and the electrometallurgical fields and the unanimous conclusion reached is the one recorded in the recently published detailed report of the United States Federal Power Commission:[1–3] The electrochemical industry is the only one in position to absorb this vast by-product power ultimately available upon completion of the various irrigation projects now under way. The by-product power will total more than 2,000,000 kw, a goodly proportion of which is far from the main manufacturing centers or markets for power.

There is hardly any need to discuss the fact that electric power is cheapest when generated at or near the place of consumption. Furthermore, it has been pointed out repeatedly that "the trend in power-cost reduction is in the direction of less expensive and better operating fuel-burning plants—not toward Diesels or hydroelectric plants".[4] The experience of the Pacific Gas and Electric Company is too well known to need repetition here.

At all events, with low price and steam-electric power available in most of the present manufacturing centers, what solution have we to offer as to the utilization of the excess power derived from the Government irrigation projects?

Transmitting electric power to manufacturing centers several hundred miles away is costly—much more costly than transporting fuels to these centers. Admitting that under present conditions and with present means power transmission to any great distance, say beyond 250 miles, is highly uneconomical as compared with the transportation of fuels, it may very well develop, as Doctor Karl T. Compton, chairman of the Science Advisory Board, announced five years ago, that entirely new methods of transmission, such as the evacuated pipe line, will make it feasible to transmit electric power to towns and industrial centers many hundreds of miles distant from generating stations.

But even with very low transmission costs, we are ultimately confronted with the fact that the many thousands of kilowatt-hours, soon to become available, must be absorbed in electrochemical industries.

## Raw Materials

As to raw materials for the production of aluminum, ferroalloys, magnesium, and other electrochemical products, there are deposits, some very extensive, of a large variety of ores in widely distributed localities in the country. Thus, for example, very large deposits of phosphate rock, suitable for electric-furnace conversion into

Address presented at a meeting of the AIEE New York Section, November 14, 1939.

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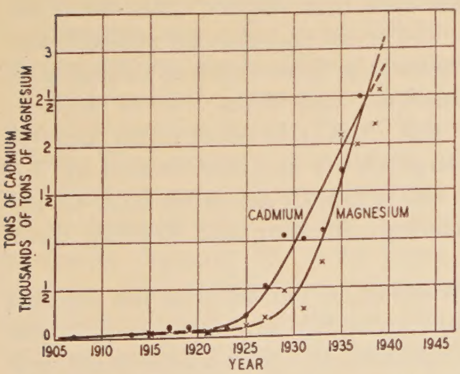



Figure 1. Production of magnesium and cadmium in the United States

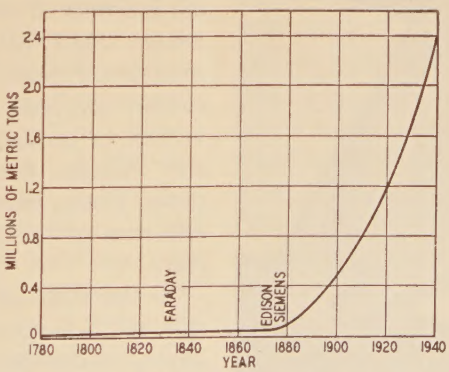



Figure 2. World's production of copper

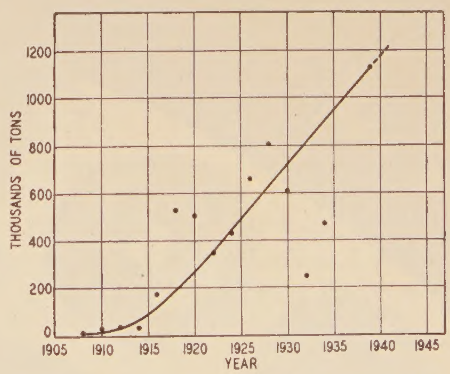



Figure 3. Production of electric furnace steel in the United States

phosphate fertilizers, are located in Idaho, Wyoming, Utah, and Montana. We are no longer limited to the use of high-grade phosphate rock. As a result of discoveries and advances made in flotation we can concentrate low-grade phosphate material into grades suitable for the electric furnace.

Magnesite, native magnesium carbonate, is found in California and elsewhere. Magnesite is the raw material for the new electric-furnace process for the production of magnesium by reduction and volatilization—possible only through high electric heat. The heat of formation of magnesium oxide ($MgO$) is 610 kilojoules as against 146 for copper oxide ($CuO$).

A mixture of dead burned magnesite ($MgCO_3 \rightarrow MgO$) and coke is fed between electrodes of a 2,400-kw three-phase electric furnace. The furnace is of the closed or sealed type, and the entire charge is volatilized at a temperature approximating 2,300 degrees centigrade. The reaction $MgO + C = Mg + CO$ is reversible, and upon *slow* cooling we get back $MgO$. However, if the magnesium vapor together with the carbon monoxide, as they leave the furnace and pass through a pipe to the condenser, are suddenly chilled by injecting a large volume of hydrogen, then the reformation of $MgO$ is prevented, and magnesium metal collects in the condenser. This electric-furnace process is competing with the older fused-magnesium-chloride process.

The magnesium industry has had a phenomenal growth during the last few years, as the curve in figure 1 illustrates. The supply of the metal has exceeded the demands of the automotive industry. Dow Metal, the trade name for the most important magnesium alloy, has found numerous uses, such as I beams and other structural materials, airplane parts, motor fans, foundry flasks, motion-picture cameras. The aircraft industry consumes more than half of the total magnesium produced.[5]

Deposits of low-grade manganese ore suitable for the electrowinning of manganese are located near several of the new power sites. A recently established electrolytic manganese plant is at Knoxville, Tenn., next to the Government-built Norris Dam and close by the Tennessee manganese-ore deposits. The process[6] here applied is that of leaching native low-grade high-silica manganese ore with acid-ammonium-sulphate solution and electrodepositing manganese at the cathode. A recent improvement in the process[7] eliminates the loss due to manganese peroxide formation at the anode by catalyzing the evolution of oxygen in preference to the formation of manganese peroxide. We are fully confident that this new electrolytic process, as it is amenable to our poor-quality native ores, will make the United States independent of high-grade imported ores—emanating from Russia, South Africa, Brazil, and elsewhere, and constituting today about 95 per cent of domestic consumption.

**Figure 4. Die castings of magnesium alloy**

Courtesy Dow Chemical Company

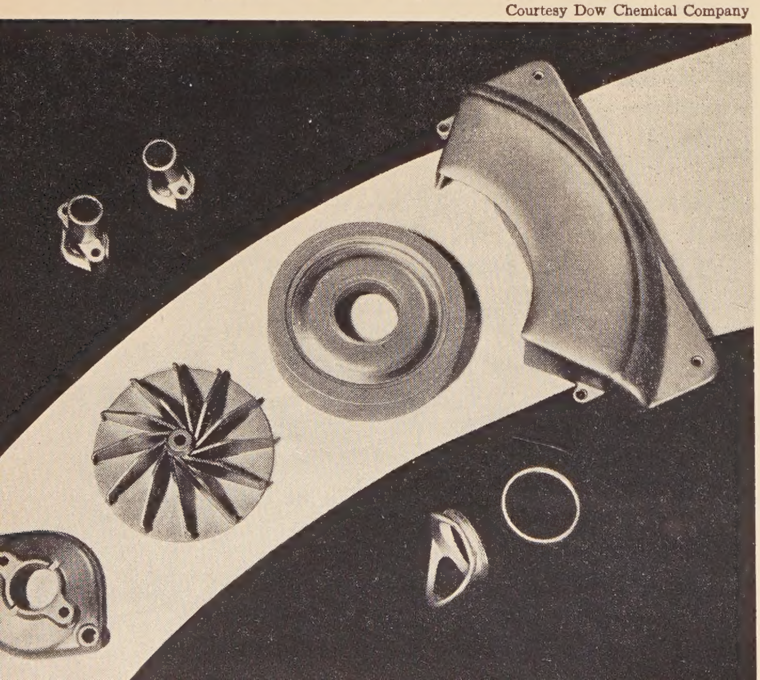


**Table I. Annual Electric-Energy Consumption by a Few of the Electrochemical Industries (World Output)**

| Product | Thousands of Tons Produced | | | Millions of Kilowatt-Hours Consumed | | |
|---|---|---|---|---|---|---|
| | 1919 | 1929 | 1939 | 1919 | 1929 | 1939 |
| Aluminum | 150 | 300 | 600 | 3,700 | 7,000 | 13,500 |
| Copper (electrolytic) | 900 | 1,800 | 2,200 | 250 | 600 | 730 |
| Zinc (electrolytic) | 70 | 500 | 600 | 240 | 1,500 | 1,800 |
| Caustic and chlorine | 150 | 400 | 2,400 | 400 | 1,140 | 7,000 |
| Calcium carbide | 900 | 1,600 | 2,600 | 2,520 | 4,160 | 6,200 |
| Electric steel | 800 | 2,200 | 2,500 | 480 | 1,100 | 1,200 |
| Ferroalloys | 220 | 550 | 600 | 1,320 | 3,000 | 3,300 |
| Abrasives* | 50 | 150 | 180 | 280 | 750 | 900 |
| Total of products listed | 3,240 | 7,500 | 17,080 | 9,190 | 19,290 | 34,630 |
| Estimated grand total† | 3,500 | 10,000 | 23,000 | 10,000 | 21,000 | 39,000 |

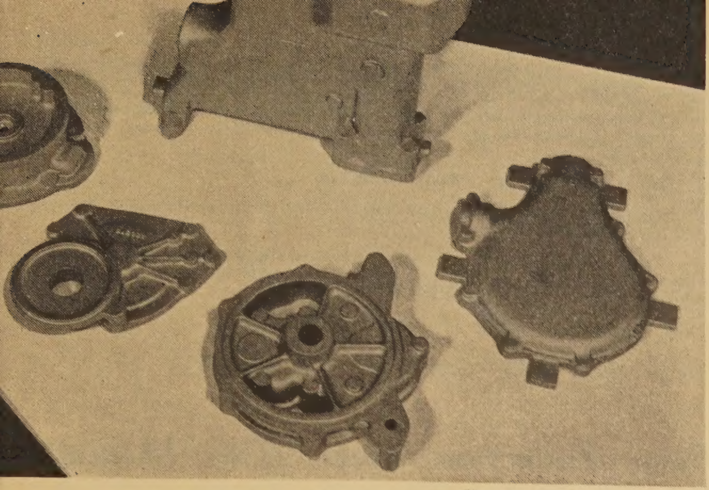
* Silicon carbide and artificial emery.

† Includes products not listed, such as graphite, nickel, chromium, lead, silver, gold, cadmium, magnesium, sodium, phosphorus, carbon bisulfide, hydrogen, and oxygen.

Tungsten ore for the electric-furnace production of high-speed steels and other important alloys is found in a dozen western states. The largest producer is Nevada, the home of Boulder Dam. In Nevada, too (Humbolt County) are found high-grade alunite deposits suitable for the electrolytic production of aluminum.

The world's aluminum production has doubled during the last ten years, just as it did in the previous ten years (see table I). The demand for the metal is ever increasing, for such uses as: airplane engines and bodies; street cars and streamlined trains; locomotive cabs (3,000 pounds lighter than steel cabs); and high-voltage transmission lines of which more than 700,000 miles are in use today. Many other native raw materials are available and suitable for electrochemical processes such as coking coal, chrome ore, salt, limestone, and fluxes. As to the conversion of ordinary salt ($NaCl$) by electrolysis into lye and chlorine, two large plants are now located at Tacoma, Wash., where also is located one of the large copper refineries of the American Smelting and Refining Company.

In the state of Washington too are iron ore deposits that we believe could profitably be converted into iron pipe by electrochemical methods. This scheme is not new. Two French engineers, Boucher and Bouchayer, produced thin-walled iron tubes at Grenoble for a number of



Courtesy Dow Chemical Company

**Figure 5. Sand-cast aircraft-engine parts of magnesium alloy**

years. Figure 7 shows a section of pure-iron pipe nine inches in diameter with a one-quarter inch wall, which was made at the Columbia University laboratories. A new chloride solution was developed that served as electrolyte.[8] The cathode was a steel mandrel rotating at a peripheral speed of about 350 feet per minute. Pure iron was deposited at a current density of 100 amperes per square foot. Cost estimates for 30-foot pipe on the basis of five-mil power indicate that electrolytically deposited pipe is decidedly cheaper than drawn pipe. Another factor that favors electrolytic pipe is the ease with which iron ore can be leached—in this way dispensing with furnace operations entirely.

## Markets

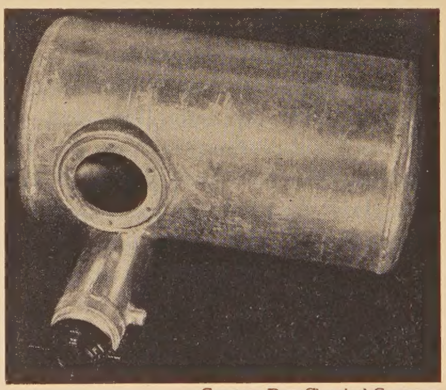
There is no question as to availability of cheap electric power at the irrigation-project centers. Nor is it primarily a question of availability of raw materials for various electrochemical processes. Many engineers believe that the immediate question is that of *markets*. Will it be possible profitably to dispose of aluminum or magnesium or calcium carbide made in Oregon or in Washington, or in Nevada, or in Tennessee? Frankly, I am of the belief and opinion that, after the establishment of the new electrochemical centers, the markets are bound to follow. To set up an alkali-chlorine plant at Tacoma would have been considered a very foolhardy undertaking a generation ago. Yet today the two plants at Tacoma are turning out 20-odd different products and selling them.

The Aluminum Company of America has just recently signed a contract for the use of Bonneville hydroelectric power. The contract calls for 32,500 kw. A 200-acre plot has been acquired in Vancouver, Wash., and the new electrochemical plant to be built will have an initial producing capacity of 15,000 tons of aluminum per annum. The standard fused-electrolyte process of Hall will be used which requires as much as 11 kilowatt-hours per pound of aluminum produced (table I).

In discussing this question of markets for electrochemical products that will be made at these new hydroelectric centers, it may be interesting to recall the birth and development of the automobile-manufacturing center at Detroit, Mich. As has been fittingly and repeatedly stated, "Niagara Falls made Detroit possible"; in other words, without the electric-furnace products such as ferroalloys, abrasives, and others made at Niagara Falls, the automotive industry would not have progressed as rapidly as it has. Without electric-furnace products the modern automobile would be nonexistent. Yet it was necessary during the early years of the automotive industry (and to a large extent still is) to ship ferroalloys from Niagara Falls to the steel centers at Pittsburgh, Pa., and elsewhere and from there ship the various alloy steels to Detroit—a total distance of 400 miles—before final utilization in an essential component of the automobile.

Just as our Government at Washington has been confronted with the problem of water-power utilization, so likewise has London been studying the utilization of the huge power of Victoria Falls in Northern Rhodesia, Africa, the potentialities of which exceed by far those of Niagara. From 20 to 60 million gallons of water daily has been passing over the brink of Victoria Falls for 85 years since their discovery by David Livingstone. And it was only a year or so ago that the first step was taken to utilize even a very small fraction of the power. In March 1938, a 4,000-kw hydroelectric plant was completed. The first two of the four units are in operation and are supplying electric power to the nearby town of Livingstone for lighting and motor requirements.[9] This is a small beginning—4,000 kw at Victoria Falls as compared with 1,200,000 kw of generated and consumed hydroelectric power at Niagara Falls—yet British engineers are fully aware and hopeful of the possible future developments.

**Figure 6. De-icer-fluid tank for aircraft, fabricated from magnesium-alloy sheet**



Courtesy Dow Chemical Company

Sir Alexander Gibb, past president of the British Institution of Chemical Engineers stated[10] rather pointedly: "Niagara now offers every facility to the manufacturer except really cheap power; and isolated and almost inaccessible Canadian sites are in consequence being exploited in preference by those who can afford to do so. . . . The electrochemical load is the basis of the economical production of electricity, and economically produced power is a *sine qua non* of the electrochemical industry. To the interaction of these two interests has been due more

than to anything else the great development of cheap power."

Africa's potential water power is threefold that of North America; and her mineral resources outstrip those of any other continent: copper, phosphates, chrome ore, gold, manganese, radium, cobalt, asbestos, and others. I can foresee a great electrochemical future for Africa.

## Conclusion

In conclusion there is just one other factor these new electrochemical centers at the various dam sites will have to reckon with, and that is the supply of engineering talent. Young men are needed who not only are conversant with the electrical features of electric furnaces, electrolytic cells, fused electrolytes, and other electrochemical apparatus, but these men must be familiar with the chemistry of the reactions involved; they must be able to sample an electric-furnace heat and in a few minutes determine whether or not the product meets with the close specifications laid down by the consumers. Not only must these young men be electrical engineers, they must be chemical engineers as well.

Figure 7. Section of pipe made by the electrodeposition of iron on a steel mandrel

Here lies an opportunity for the young engineers entering our universities today: They should so select their course of study as to fit them for the new electrochemical plants that are bound to spring up in various sections of the country. With the active support of the young engineers, the electrochemical industry in America is bound to go forward with even greater strides than it has in the past 30 years.

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# Paint Reflection Tests With Mercury and Incandescent Lighting

RESULTS of a series of tests made on surfaces painted with 21 different commercial interior tints, under both mercury and incandescent illumination, should prove helpful in selecting colors for use with various types of lighting equipment. The tests were made by the lamp division of Westinghouse Electric and Manufacturing Company, under the supervision of S. G. Hibben (A'34) director of applied lighting.

White had the highest reflection value of the 21 light tints tested, indicating that with indirect or semi-indirect lighting equipment which casts much of the light upward, white should be used for ceilings. Colors for interiors should be chosen not only for reflection value but with consideration of the wave lengths normally predominant in the output of the type of illumination used. The continuous spectrum of the filament lamp is relatively deficient in the blue-violet end of the spectrum; that of the mercury lamp, in the red end.

The basic standard of comparison for the tests was a surface of magnesium carbonate with a reflection coefficient of 98 per cent. The illumination from the filament lamp corresponded to that of the medium-wattage Mazda lamps in ordinary store or office use. The mercury illumination was from a standard 250-watt high-intensity mercury-vapor lamp at about one-half atmospheric pressure, operated at a stable temperature and normal rating. Illumination in all tests was diffuse.

The tests showed the average coefficient of reflection for the 21 colors to be about two per cent higher under mercury illumination than under incandescent. For mercury the average was 0.679; for incandescent, 0.657. "Satin white," the tint with the highest reflection value, had a coefficient of 0.87 for mercury lighting; 0.85 for incandescent. However, pinks, buffs, tans, and reddish tints had slightly higher reflection values with incandescent illumination than with mercury.

To determine comparative reflective values, the 21 tints were divided into three reflection coefficient groups: above 75 per cent, 60 to 74 per cent, 45 to 59 per cent. Under incandescent light, each group contained seven tints. Under mercury light, the groups shifted, the first containing only four tints, the second ten, and the third, which corresponded with only one exception to the same group under incandescent lighting, seven tints.

# The Role of Science in the Electrical Industry

M. W. SMITH
MEMBER AIEE

***Behind the phenomenal growth of the electrical industry lies an important fact: "The industry has consistently accepted and adapted to its own use the new ideas and developments of science."***

THE STORY of the electrical industry is one of growth in giant, breath-taking strides and great technical advances. Turbine-generator units have progressed to the stage where ratings of 100,000 kva at 3,600 rpm and 300,000 kva at 1,800 rpm can now be built. Hydraulic generators, the size of which may ultimately be limited by manufacturing facilities because of their large diameters, have exceeded 100,000-kw rating. Efficiencies of some of the large hydrogen-cooled turbine generators, synchronous condensers, and frequency changers have approached 99 per cent in individual units. Transformers have increased to present-day ratings of over 150,000 kva per bank, and efficiencies of well over 99 per cent have been realized. Circuit breakers are capable of interrupting several million kilovolt-amperes—equal to that of the short-circuit capacity of some of the large interconnected systems. Lightning arresters are available with sufficient capacity to handle a direct lightning stroke of over 100,000 amperes and yet limit the voltage to safe values.

Behind this growth, the rate of which has shown no diminution since the birth of the industry, lies a significant, important fact. The industry has consistently accepted and adapted to its own use the new ideas and developments of science. In fact the industry has fostered and encouraged fundamental research to the point that the research laboratory has become an integral part of the industry itself. It also recognizes the value and importance of the scientific accomplishments of the universities and other research institutions, and maintains a close contact with their work.

Although the industrial laboratory has become the basic element in the electrical industry, the manner by which its fruits are put to practical use is complex. Not only are there many ways by which a new idea is transformed into a practical thing, but also there are many problems in connection with making the fullest use of scientific effort. These ways and these problems merit a closer examination.

## Efficient Use of Science Presents Many Problems

The task of the industry is not only to uncover new principles and make new discoveries, but also to determine which ones can be put to practical, profitable use, and how. It is difficult to recognize the potential value of new discoveries and to determine at an early stage the possibilities of applying them to industrial processes and products.

### The Problem of Timing

The rate of application of new ideas is not dependent solely upon the time necessary to conceive and develop them. It is also influenced by the time required for public acceptance. Household refrigeration, the basic principle of which is very old, required a relatively long time for both instrumentalities and public acceptance. Numerous problems had to be solved in the commercial development of such items as suitable refrigerants; sealed compressor shafts or the alternative of hermetically sealed units; systems of proper lubrication that would be effective for a period of years; elimination of noise; quantity production methods such as those previously developed in the automobile industry; electric-welding methods; and many other items, including even such things as a system of time payments.

During the first two decades of radio the efforts of radio engineers were directed toward developing methods by which radio could be used as a means of private communication. It remained for a new idea, the opposite of this notion, to allow radio to assume its present stature. Public acceptance of radiobroadcasting was almost instantaneous. This case is an exception to the rule that the exploitation of new products and devices usually results in unprofitable operation for prolonged periods.

The course of carrier current also supports this point. In the middle 20's carrier current came into successful use for communication along transmission lines. Then came a quiet period of several years in its development, followed about 1935 by an intensified activity which shows no signs of any immediate slackening. The need for high-speed relaying of long lines, the development of better tubes, and other changes in the industry spurred engineers to adapt the fundamentals of carrier current to relaying and supervision as well as communication.

Spot welding has been a practical, though limited, industrial tool for many years. However, some six or eight years ago, the idea was conceived of using the ignitron to control exactly the duration of the welding current. Since that time, spot welding has grown enormously both in total use and in diversity of applications. The ignitron,

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incidentally, was originally developed not with welding in mind but to increase the reliability of mercury-arc rectifiers.

### The Problem of Obsolescence

The industrial laboratory poses the inexorable problem of obsolescence. Fortunately the leaders of the electrical industry have taken the farsighted view that, in order to make sound progress, the seeming ruthlessness of obsolescence must be accepted. Unless one has studied the rates of development and consequently the rates of obsolescence, it is seldom realized how relentless is the march of progress.

A plant that is modern today may be out of date tomorrow. As a matter of fact, the more progressive companies attempt to anticipate obsolescence. Capital expenditures are made on the basis of the time at which the new plant or equipment will be obsolete, not when it is worn out.

The discovery of a new fact in science may completely upset an existing design. Even though the style or performance of a product may not be greatly modified, the practice of the art or process by which it is produced may be radically changed. With the steep rise of welding not long ago, in a few short years the method of constructing most large machines swung from casting to welded fabrication. Neither the appearance nor the performance of the machines was fundamentally altered by this change; the principal motive is economy of time and of construction cost.

It behooves all managements to keep themselves keenly alive to the necessity of meeting changes resulting from progress. Of all competition, there is none quite so ruthless as that which replaces. We all can remember that during the early stages of radiobroadcasting, several plants rapidly grew up for the making of radio headsets. The development of the loud-speaker practically ruined this active business. The early sets used vacuum tubes supplied by direct current, requiring plate and filament batteries. This created a heavy production of dry batteries that was subsequently curtailed by the development of plate-battery eliminators. Later, the development of the copper-oxide rectifier eliminated the use of the storage battery for filaments, and still later, the development of a-c tubes so completely changed the design of radio receivers that it rendered many inventories and factory equipments obsolete.

The most recent step in this evolution—and one that shows the cyclic character of many industrial developments—is the battery-operated portable set that has suddenly become so popular. It is additionally significant that although a tube development displaced the early battery set, another development of tubes brings the battery back—the perfection of a tube that operates successfully on $1^1/_2$ volts.

This last development also shows the rewards from the policy of letting the obsolescence caused by science take its seemingly ruthless course. The new battery-operated radios do not offer new competition for established types of radio sets, but instead simply create or uncover an additional demand for radios. The demand for batteries and for tubes promises to reach an all-time peak.

Similar successive steps of development occurred in illumination. A large kerosene-lamp industry was rendered obsolete, particularly in metropolitan districts, by the coming of the gas mantle. It, in turn, was replaced by the electric lamps. Now a new family of lamps—the gas-discharge lamps, which include sodium-vapor, high-pressure mercury-vapor, and fluorescent units—with efficiencies several times those of incandescent lamps, have demonstrated their practicability. It is still too soon to predict to what extent they will become the universal illuminants, but there is more than a hint that illuminant evolution is not at an end. No one in the industry thinks for a minute that the more efficient light sources presage a decrease in the requirements for energy or equipment. On the contrary, as in the past, this improvement should promote further expansion.

## Industry Finds Many Benefits From Organized Research

The industrial laboratory has served the march of electrical progress in many ways. Not the least of these is that it has served to bring the scientist, the design engineer, and the application engineer into closer contact. They now talk the same language and use the same tools. Universities are giving more attention to the training of industrial scientists, and, within the last few years, important meetings have been devoted to discussions of the application of physics to industry.

The co-operation of university and industrial scientific effort has also contributed much to the progress of development by bringing scientists of different training closer together on specific problems. For instance, much of the recent progress in the improvement of insulation for electrical apparatus has resulted from the combined efforts of physicists, chemists, and electrical engineers working harmoniously in close-knit groups. For many years, only a limited number of scientists in the universities had shown any interest in dielectrics, particularly solids. The engineer stumbled along rather blindly, and little progress was made until all phases of the problem were co-ordinated through the industrial laboratory. This relationship not only has served an important function in co-ordinating the efforts of individuals, but also has exerted a strong influence in bringing together the various departments within an organization as well as outside agencies on problems of mutual interest. A new development for one department is often seen to be of value to another. Thus, research acts as a clearing house for information and stimulates its flow from one department to another.

### Joint Research Between Manufacturer and Supplier

Another co-ordinating function of the industrial laboratory is the co-operative work between electrical manufacturers and the suppliers of raw materials. For many years, electrical manufacturers have carried on co-opera-

tive research with manufacturers of steel, carbon brushes, insulating materials, and other raw materials. As a result greatly improved materials have been developed. These in turn enable the electrical manufacturer to build more reliable and more efficient apparatus, which can be extended into new and larger fields of application.

### Industrial Research Shortens Time Between Discovery and Use

Another important accomplishment of the industrial laboratory has been to effect a marked reduction in the time between the discovery of a new idea and its commercial application. For example, only a few years ago scientists conceived the idea of using as a germicidal agent a certain type of lamp the rays from which are lethal to bacteria. In the last two or three years the resulting Sterilamp has been put to regular daily use in tenderizing meat, retarding spoilage of foods, killing bacteria on drinking glasses, helping to prevent infection following surgical operations, and many other important tasks.

Even today, however, special attention must be given to this phase of the problem: After the research work has been completed and the theory or principle of operation has been verified, there still remains the decision as to the commercial possibilities of the new device or product. Usually sufficient information is not available at this stage on which to base an intelligent decision. Information as to probable costs (including equipment investment), processes, production methods, market analyses, and distribution methods must be obtained before a decision to manufacture and sell can be made. This requires that the new product be carried through some preliminary stage of development, where a study of these factors is made. Usually this takes the form of some kind of pilot-plant activity under the direction of a special experimental or development group that has the responsibility of carrying new products through this incubation stage following the completion of research work. This form of development is particularly conspicuous in the chemical industry.

### Patent System Stimulates New Developments

Our patent system has had a stimulating influence on industrial research and developments in the electrical industry that should not be overlooked. It costs money to develop and exploit inventions. The protection afforded by patents provides an incentive to develop new things under conditions such that they may be exploited long enough to become established. Quite often a strong urge toward a particular development seems to become manifest and inventive effort starts simultaneously in many places. This seeming chaos that theorists would like to control from some central throne eventually turns into true co-operative effort through the practical necessity for cross-licensing of patents before a useful product can be obtained. Television is a present-day example. Patents themselves are published and the protection afforded does away with the necessity for secrecy. The new progress that has been made impinges upon other minds, thereby starting new chains of ideas that result in co-ordinated group effort leading to rapid progress.

Without the protection provided by patents, capital would be reluctant to venture into new fields. Industrial research would become secretive, and because of the resulting lack of co-operation and co-ordinated group effort, our progress in technical accomplishments and standards of living would be seriously retarded.

In the light of these advantages, many times verified by experience, it is disturbing to observe the tendency in some political circles to propose legislation that would destroy these values and place serious limitations on individual rights. Even the uncertainties surrounding such proposals create a lack of confidence, tending to retard initiative and technical progress. This same condition exists to a large extent throughout the industry, and particularly in the public-utility field where political threats and limitations have seriously curtailed expansion and thus retarded the use of scientific developments directly in the generation and distribution of electricity.

## Electrical Industry Draws From All Basic Sciences

Contributions to the development and progress of the electrical industry have come from practically every branch of the basic sciences. This is not surprising when we consider the large variety of materials used in the manufacture of electrical equipment.

### Metallurgy

Improvement in electrical apparatus is largely dependent on the improvement made in the properties of the materials used. This applies to both physical and chemical properties of various kinds. The limitations in physical properties of materials are most likely to be encountered in high-speed rotating machinery such as steam turbines, where centrifugal and steam forces are likely to be large under conditions of high temperature, which in turn tends to lower permissible stress limits.

Research work done in recent years by both electrical and steel manufacturers to determine and improve the fatigue, creep, corrosion, and other physical properties of various alloy steels used in highly stressed machines has resulted in such marked advances in design that output ratings have been more than doubled at the highest operating speeds in less than five years.

The electrical industry has also called on the metallurgist for new and improved magnetic steels and alloys. Magnetic steel, particularly electrical sheet steel, has been a subject of continued research by both electrical and steel manufacturers. This has involved studies of molecular and grain structures as well as of chemical compositions and purity. This work has resulted in a steady decrease in iron losses in the cores of transformers and machines of such magnitude that they have been reduced by more than half in the last 20 years, with a saving to the industry of millions of dollars annually.

Until recently, the improvement in electrical sheet steel was confined largely to iron losses. Practically no improve-

ment in permeability had been accomplished. As a result of recent research and development we now have a magnetic steel that has not only lower iron loss but also much better permeability.

New alloys are sometimes discovered and developed as by-products of other research work. In the electrical industry, the need for new alloys with special characteristics often arises in connection with new electrical developments. It is therefore often necessary to develop special alloys to meet limitations encountered in electrical developments, particularly when the volume required is too small to be attractive to alloy manufacturers. For example, a recently developed alloy containing only a few per cent iron, is stronger at 1,100 degrees Fahrenheit than any low-carbon steel at room temperature. It creeps very little. It survives a 6,000-hour creep test at 1,000 degrees Fahrenheit that causes cast carbon-molybdenum steel to fail and high-strength nickel-chromium steel to creep 100 times as much. As an amazing demonstration of how it retains its elastic properties when hot, a bar of steel and one of this alloy were heated to 1,100 degrees Fahrenheit. When struck with a hammer, the steel bar responded with a dull thud; the alloy with a clear, bell-like tone.

### Chemistry

The application of chemistry to the electrical industry has been almost unlimited. Chemists have been called on principally to produce new and improved insulating materials, compounds, varnishes, oils, etc. There have been many other developments, however. For example, a fireproof chlorinated compound has been developed to replace transformer oil in applications where fire hazards exist. Many fireproof liquids have been made available, but a great amount of research and development work has been required in recent years to obtain a material that also had satisfactory electrical properties such as high dielectric strength, low power factor, and viscosities comparable with transformer oil, particularly at low temperature.

### Physics

The foundation of the electrical industry is supported to a large extent on the laws of physics. Some of the most important scientific discoveries and applications therefore have come from this field. The discovery of electromagnetism, the electron, and the X ray are outstanding examples. From researches on the mechanics of the ion came the principle of circuit interruption by deionization that has been applied to a whole family of interrupting devices from the giant circuit breakers that handle millions of kilovolt-amperes down to the new practical circuit breakers for the home that are little larger than a wall switch. In the field of electronics, numerous electrical developments of far-reaching importance have been based on these and similar discoveries.

### Mathematics

Probably no other industry rests on such a precise mathematical basis as the electrical industry. From its very beginning its every step in the design, construction, and operation of electrical apparatus has been guided by computation. In fact, the electrical engineer has invented several mathematical tools to serve his purposes, such as the complex quantity and symmetrical components. He has even placed his mathematics on a mechanical basis, such as that amazing creation, the calculating board.

Pure mathematical concepts have given birth to many electrical devices. Particularly has this been true of relays for the protection of transmission lines and terminal equipment. A conspicuous recent example is a new, simplified pilot-wire relay that greatly extends the practical field of this type of relaying. This relay was conceived directly from the mathematical conception of positive, negative, and zero-sequence components of alternating currents.

## As to the Future

We know so little about nature's basic underlying principles that it is incredible that anyone should think that our knowledge of natural laws is anything but exceedingly small when compared with the vast amount that is listed in the unknown column. This alone should be encouraging, for if we can accomplish all that we have with such a poor understanding, it is reasonable to expect vastly better results as we obtain more basic knowledge.

While our human limitations may prevent us from seeing very far into the future, present developments give us some idea of future trends and in what fields expansions are likely to occur.

In the processing industries, electricity will probably assume an increasingly important role in the way of metering, regulating, and controlling numerous phases of new as well as existing processes. Recent improvements in electric furnaces and their controls, including the control of the atmosphere inside of the furnace as well, indicate various possibilities in this field. For instance, heat treatment of steel sheets for automobiles by continuous processes in less than 15 minutes has been accomplished. In the presence of highly purified atmospheres, various steels and alloys can now be bright-annealed. In controlled-atmosphere furnaces, dies can be heat-treated without oxidization or carburization, thus eliminating subsequent grinding.

In the broad field of air conditioning, electricity will play an important part, not only in applications requiring power but in the processing and treatment of the air itself. Electrical means are now available for cleaning and sterilizing air. These new aids in air conditioning, coupled with the available services of heating, cooling, and humidity control, make it possible to improve man's living conditions so profoundly that he may live in a clean spring or fall atmosphere all the year around in any locality.

Lightningproof electrical systems were but the dreams of engineers a few years ago. They are still not a reality, but the day is coming when they will be. Much has been done in this direction; more is yet to be done. The recent development of a device for recording natural lightning strokes that is relatively inexpensive and simple,

so that dozens of them can be installed over wide areas, will be of tremendous assistance in collecting that quantity of statistical information about lightning necessary for the construction of protective devices and self-protecting apparatus. We now have reason to believe that in the not too distant future lightning, once the great disturber of electrical systems, will be eliminated as a hazard to power continuity.

Vast new vistas are being opened by high-frequency electric energy. High frequencies, which broadly include everything beyond 60 cycles, are already being used for numerous tasks of melting, heat-treating, and drying. Packaged raw materials are being dried without opening the containers; bearing surfaces of finished engine crankshafts are being given additional hardness by localized heating induced by high-frequency currents. With the rapid developments in high-frequency generators, both of the rotating and electron tube types, it is not inconceivable that all gasoline and Diesel engines, machine tools, and other machines will be treated by high-frequency when assembled or partially assembled to harden the wearing surfaces.

The great field of electronics, which is now best known in radio, television, and communication, can be expected to find a greater number of future applications in the electrical industry, particularly in those fields having to do with automatic machine operations, inspection of materials and safety methods. Recent progress in the development of larger and more reliable metal-tank tubes indicates that electronics may also be expected to play an increasingly important part in electric-power distribution, both in transformations and control.

When it is considered that the power consumption in many small homes today is from three to ten times the national average, due to the increasing acceptance of electric ranges, water heaters, forced air circulation, high lighting levels, and other conveniences, we can expect domestic power consumption to double in a reasonable time. This indicates the need for an improved low-voltage distribution system as well as rewiring of homes.

Agriculture is another field that has scarcely been touched by the electrical industry. In addition to the usual applications of power and light, there appear to be many possibilities of applying treatments and radiations for the stimulation of plant growth and control of insects that now infest grains, plants, and seeds.

Present researches in nuclear physics in many institutions may result in obtaining information that will be just as extensive in its influence on the developments in the electrical industry as was the discovery of the electron. The production of radioactive substances, through the disintegration of the atom may provide a very useful tool. Naturally, one thinks of using these radiations instead of the X ray for radiography or for radium in the treatment of disease. While they no doubt will be used to some extent for such purposes, the possibility of using these radiations as a means of studying certain atomic reactions and structures may be even more useful. For instance, by the use of electrical detection methods, it appears feasible to follow the migration of radioactive atoms through a metal during heat-treating processes. Similarly, it is possible to trace the movement of radioactive substances through a plant or the human body and thus learn more about how and where these substances are assimilated. In contrast to radium, most of these artificial radioactive substances have such a short life that no permanent harm is done to the human system.

The present methods of generating electric power are so well established that we are inclined to accept them as permanent. Gradual improvements in present methods have reduced the amount of coal used per kilowatt-hour to approximately one-fourth that required 20 years ago. While this improvement is indicative of real progress in steam power generation, it is still small when compared with the theoretically possible energy that could be gotten from a highly efficient method of energy conversion.

With an increasing knowledge of the fundamental properties of matter and a better understanding of the conduction of electricity in gases, recent calculations and experimental work indicate that it may be possible to use the electromagnetic properties of the rapidly moving ionized products of combustion of certain fuels in conjunction with some suitable electrical transforming device as a means of generating electric energy. A practical development of this idea, which at least appears to be a possibility at the present time, would result in the use of static electrical devices extracting power from the kinetic energy of the gases of combustion without the intervention of rotating electrical machinery.

Although these and many other prospective developments that might be mentioned are indefinite and difficult to evaluate, we can look forward with the expectation that the electrical industry will continue to grow under the stimulation and impetus of new scientific discoveries and advances.

# New Indirect Luminaire Improves Drafting-Room Illumination

F. P. KUHL

IN PLANNING the recently completed installation of a new lighting system for the drafting rooms of the Consolidated Edison Company of New York, Inc., the aim was to eliminate glare and obtain 40 to 50 foot-candles of totally indirect light. A study of the fixtures that were commercially available disclosed that approximately eight watts per square foot would be required to obtain the illumination level desired. The heat loss at this rate would have required an air-conditioning system to maintain a reasonable room temperature. The cost of this air-conditioning system would have been at least twice that of the proposed lighting system.

The problem, therefore, resolved itself into developing a fixture that would provide the illumination level desired at a power consumption that would not require an air-conditioning system or a considerable change in the existing conduit and wiring system. In all probability, it is for these reasons that so few existing lighting systems are renovated to meet the standards advocated by the "better light–better sight" campaign.

After a further study of commercially available lighting fixtures, the silvered-bowl lamp was selected as a starting basis. This lamp has a distribution curve that is almost entirely above the horizontal line at the filament center. It also has a self-contained silvered mirror reflector which cannot deteriorate from the collection of dust and which is renewed whenever the lamp is replaced.

Having decided on the lamp and reflector, the next step was to eliminate glare and control the spread of light from the lamp. The lamp was mounted as close to the ceiling as a socket would permit, in order to obtain the shortest path of light, and various combinations of louvers and pans were tested. The final design* resulted in a combination of concentric rings or louvers as shown in figure 1. These rings are made of metal and therefore are entirely opaque, eliminating high brightness on their outer surfaces. The rings and canopy are finished in flat white. The socket husk and spider for supporting the rings are finished in fused aluminum to prevent discoloration from heat.

The concentric-ring combination overcomes the ob-

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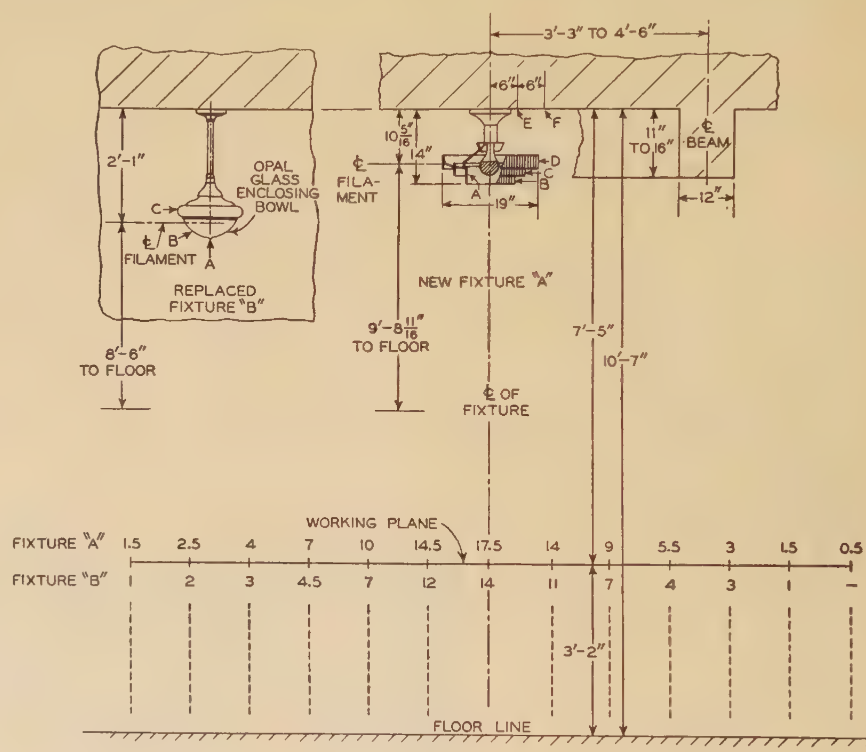
* Patent applied for; all rights reserved by the author.




Foot-candle readings on working plane, as distributed from one luminaire; values should increase slightly after ceiling is refinished

Brightness Readings; Arrows on Diagram Indicate Position and Angle of View

| Location | New Indirect Fixture "A" Reflected Brightness (200-Watt Silver-Bowl Lamp)† | | Replaced Semi-Direct Fixture "B" Luminaire Brightness | | | |
|---|---|---|---|---|---|---|
| | | | 200-Watt Lamp* | | 150-Watt Lamp* | |
| | Millilamberts | Candlepower | Millilamberts | Candlepower | Millilamberts | Candlepower |
| A | 126.6 | 0.26 | 1,770 | 3.63 | 1,280 | 2.36 |
| B | 63.3 | 0.13 | 1,480 | 3.03 | 1,090 | 2.24 |
| C | 116.9 | 0.24 | 1,237 | 2.54 | 852 | 1.75 |
| D | 33.1 | 0.07 | | | | |
| E | 564.9 | 1.16 | | | | |
| F | 231.8 | 0.476 | | | | |

* Clear Glass † Inside Frosted

**Figure 2. Intensity of illumination and surface brightness as measured with the new luminaire (A) and the one it replaced (B)**

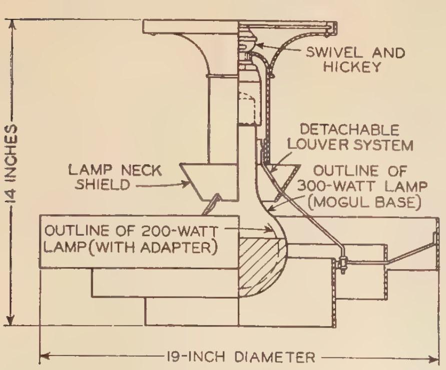



**Figure 1. Sectional view of new luminaire**

jection to the reflecting pan of the conventional indirect lighting unit in several ways:

1. Presents a minimum intercepting surface to reflected light from the ceiling.

2. Does not collect dirt and dead insects and, therefore, requires minimum cleaning.

3. Does not present the dark appearance usually found on the under side of indirect lighting reflectors.

4. Provides excellent ventilation for dissipating lamp heat.

5. Lamps can be replaced from floor with lamp changer.

Using 200-watt lamps in the final fixture, an intensity of approximately 38 foot-candles was obtained on a working plane 3 feet 2 inches above the floor at a power consumption of 3.8 watts per square foot. This indicates that 60 per cent of the light flux produced by the lamps reaches the working surfaces of the drafting boards, which is considerably higher than that obtainable from the conventional indirect fixtures. Using 300-watt lamps, nearly 60 foot-candles was realized. These values will increase slightly after the ceiling is refinished. Approximately 7 per cent absorption occurs in the louver system.

During the experiments, a group of draftsmen was subjected to various intensities ranging from 20 to 60 foot-candles while performing normal duties. Each period was of sufficient length to develop a complete reaction. It developed that reflected light from tracing cloth at levels higher than 35 foot-candles was very annoying. The reaction of the draftsmen was most favorable at 30 foot-candles. This level of 30 foot-candles was adopted as the basis of design for the final installation, and is an increase of 150 per cent over the replaced system at an increase in power consumption of slightly less than 60 per cent.

The spacing of the lamps, approximately 6 feet by 9 feet, was governed by the lattice work of the building beams covering the ceiling and by the use of existing outlets, supplemented with additional outlets wherever necessary. Beams are usually an obstacle to indirect lighting installations, flat ceilings being preferred. In this installation effective use was made of the beams to act as curtains, the fixtures being almost concealed when viewed from a distance of three bays or more. The bottoms of these beams have a low surface brightness and present a pleasing pattern on an otherwise brightly but unevenly illuminated ceiling. An illusion of increased room height and of sunlight filtering down from skylights is also created.

Figure 2 shows the distribution of light on the working plane from one new fixture, when mounted between beams as it is in this installation, as compared with the replaced semi-indirect fixture. It also gives a table of brightness readings.

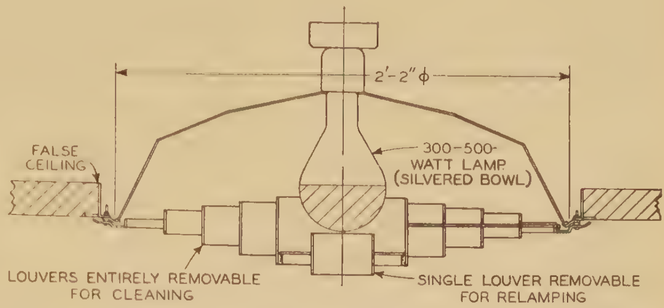



**Figure 3. Sectional view of indirect downlight luminaire for flush ceiling mounting, employing the silvered-bowl lamp and concentric-ring arrangement similar to that shown in figure 1. This illustrates the general adaptability of this design principle for other uses**

**Figures 4 and 5. Views before (above) and after (right) installation of the new luminaires, showing a portion of the drafting room which is 225 feet long and varies from 75 to 110 feet in width**

# Some Recent Steel-Mill Installations

A. F. KENYON
ASSOCIATE AIEE

**The demand for increased amounts of sheet steel, together with revolutionary developments in manufacturing equipment and processes, has necessitated the installation of many new strip mills, and in some plants large blooming or slabbing mills to supply the heavy slabs used as raw material in the strip mills.**

DEMANDS for improved quality of product and more economical production in the steel industry are just as insistent during slack periods as at times of peak operation; and even with lessened total demand, markets in certain consuming industries and for certain classes of steel products have been greatly expanded. New construction during recent years, therefore, has been not so much in the primary iron- and steel-producing facilities as in the finish-rolling and processing departments.

A chart (figure 1) showing the distribution of rolled steel products to the various consuming industries for the 16-year period 1922 to 1937 indicates a decline in the production of heavy products such as rails and plates for railroads, structural shapes and plates for the building industry, and large welded and seamless pipe for oil, gas, and water lines. Further indicated is the rise in production of light, flat rolled products such as sheets and strip for the automotive industries, and tinplate for containers; also railroads, building, and other industries are tending toward the greater use of flat rolled material in the place of heavier plates and shapes used in the past.

This demand for increased tonnage of sheets, strip, and tinplate, together with revolutionary developments in equipment and processes for manufacturing these flat rolled products, has necessitated the installation of many new hot and cold strip mills, and in some plants these in turn have necessitated installation of large blooming or slabbing mills to supply the heavy slabs used as raw material in the strip mill.

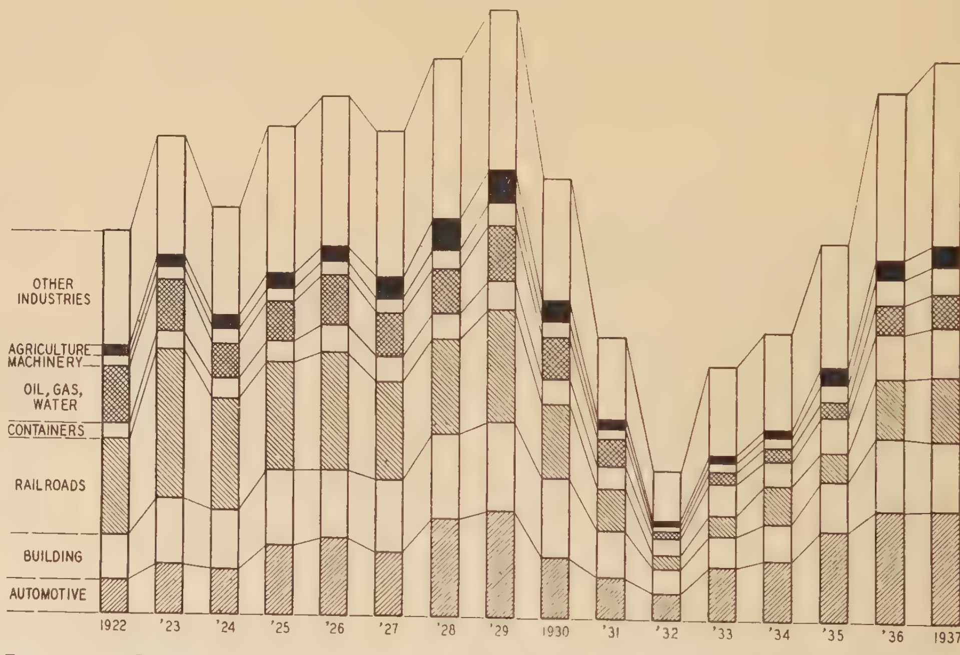



**Figure 1. Distribution of steel products to various consuming industries during a 16-year period**

## Blooming and Slabbing Mills

First step in the production of various rolled steel products is the rolling of ingots, as cast from the open hearth steel furnace, to blooms or slabs suitable for further rolling in finishing mills. Recently installed strip mills produce strip 50, 60, and even up to 94 inches wide, by several hundred feet long. These long, wide strips are rolled from slabs that may be from four to six inches thick, from 50 to 60 inches (and in one mill up to 72 inches) wide, and from 8 to 15 feet long; these slabs may weigh as much as 15,000 pounds. Demand for these extremely large slabs has forced the development of improved blooming and slabbing mills, and during the past five years there have been installed some nine or ten mills primarily intended to produce large slabs for further rolling in wide strip mills.

Wide slabs may be produced by either a universal mill having horizontal rolls to work on the top and bottom of the slab, and vertical rolls to work on the edges of the slab; or by a two-high reversing mill having only horizontal rolls and equipped with manipulators by which the slab may be turned between passes so that the edges as well as the wide surfaces may be worked by the horizontal

Essential substance of an address presented at a joint meeting of the AIEE Toronto Section and the Engineering Institute of Canada, Hamilton, Ontario, April 21, 1939.

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rolls. Most of the newer mills have been of the latter type.

A recently installed large slabbing-blooming mill illustrates the extreme height and long screws needed for raising the top roll for the edging passes on wide slabs. On this mill the rolls are 43 inches in diameter. The mill rolls ingots of various sizes up to 25 by 66 inches, 25,000 pounds maximum weight, and can produce slabs up to 62 or 64 inches wide. Figure 2 shows the top roll in the raised position. Mill spindles connecting the rolls to the driving pinions are made unusually long—27 feet between joints of the universal couplings—so that the coupling angles will not be excessive when top roll is in that position.

In each passage of the ingot back and forth through the mill, the thickness of the ingot may be reduced by an inch or more, and to make this reduction on a wide ingot requires the driving power of a 7,000-horsepower 700-volt 40/100-rpm d-c reversing motor, which is coupled directly to the mill pinions. The motor will commutate peak currents up to 23,000 amperes, corresponding to maximum torque output of 2,500,000 pound-feet. The armature is 12 feet in diameter and, with shaft, weighs 88 tons. Total weight of the complete motor is over 450,000 pounds. Figure 3 is a general view of the motor room.

The 7,500-kw variable-voltage main-power-supply motor generator set consists of five units: three 2,500-kw 700-volt d-c generators; a 6,000-horsepower 6,600-volt 3-phase 60-cycle 355-rpm wound-rotor induction motor; and a 150,000-pound flywheel, 15 feet in diameter, to equalize the fluctuating power demand of the reversing motor and smooth out the load on the 6,600-volt power system. Peak loads on the reversing motor may reach 15,000 horsepower, but with the equalization provided by the flywheel and automatic liquid slip-regulator control of the induction-motor secondary, the maximum system demand is limited to about 5,500 kw. The mill is capable of a maximum output of about 300 gross tons an hour when it is rolling large slabs.

Rolling wide slabs in a two-high reversing mill imposes severe duty on the screw-down mechanism, because of long screw movements to raise the upper roll before each of the edging passes and to lower the roll after the edging passes. Screw speeds of from 300 to 350 inches per minute are necessary in order to make these movements of 40 or 50 inches in reasonable time, and special lubrication of the screws and driving gears is necessary to avoid excessive wear and maintenance of the mechanical equipment. The electrical driving equipment must have unusual flexibility to assure accuracy in making the small movements between flat slabbing passes, as well as to provide the high speed required for the long movements before and after the edging passes. Almost invariably the screw-down mechanism is driven by two heavy-duty d-c motors, each of about 150-horsepower capacity, and in several cases a special series-parallel controller provides reasonably satisfactory performance. However, on most recent mills, variable-voltage equipment has been selected as affording the greatest smoothness and flexibility of control, together with reduced maintenance of the electrical and mechanical equipment. The slightly higher first cost is more than offset by the improved performance and greater output, and reduction in maintenance. Variable-voltage equipment also has been applied to the front and back main tables, manipulator racks, and slab shears of several mills recently completed. Two variable-voltage motor generator sets (center of figure 3) each consisting of three 150-kw generators, one 250-kw generator,

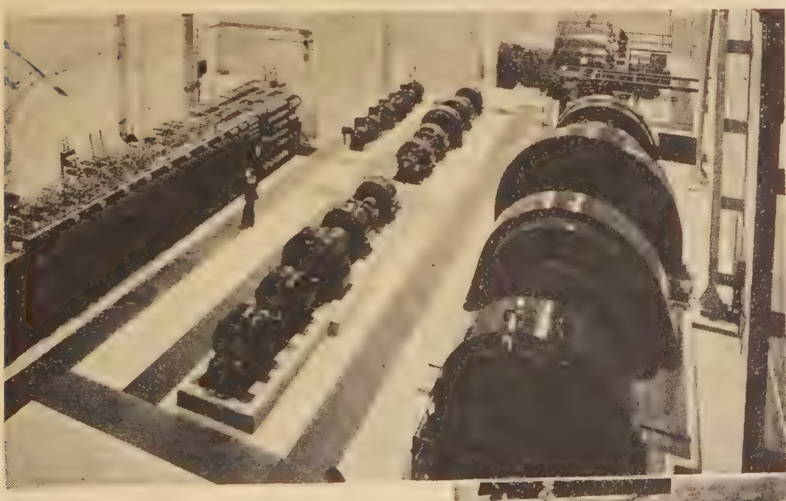


Figure 3 (above). Blooming-mill motor room. The 7,000-horsepower reversing motor may be seen in the background; 7,500-kw flywheel motor generator set in right foreground

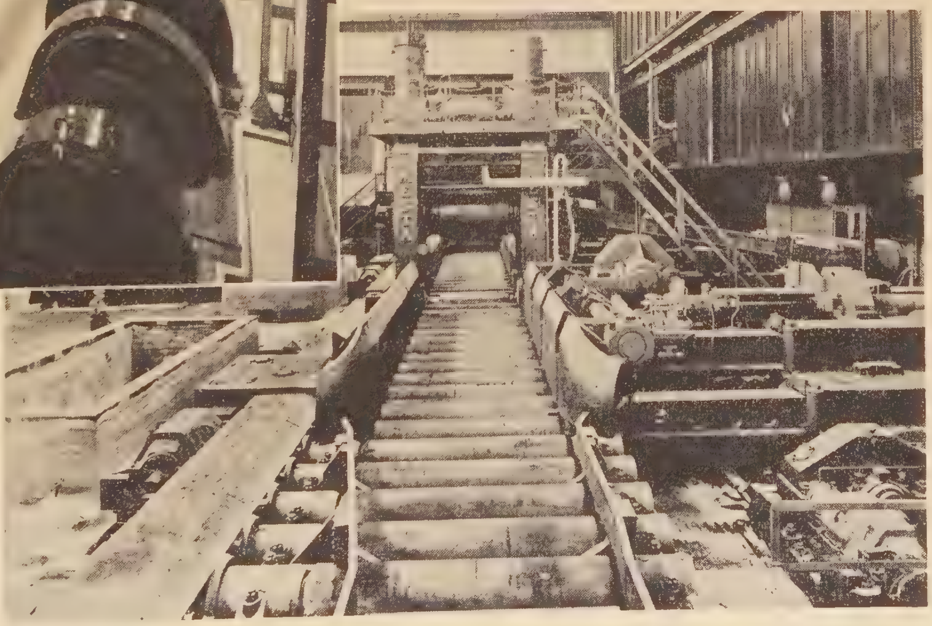


Figure 2 (below). Delivery side of a 46-inch slabbing-blooming mill

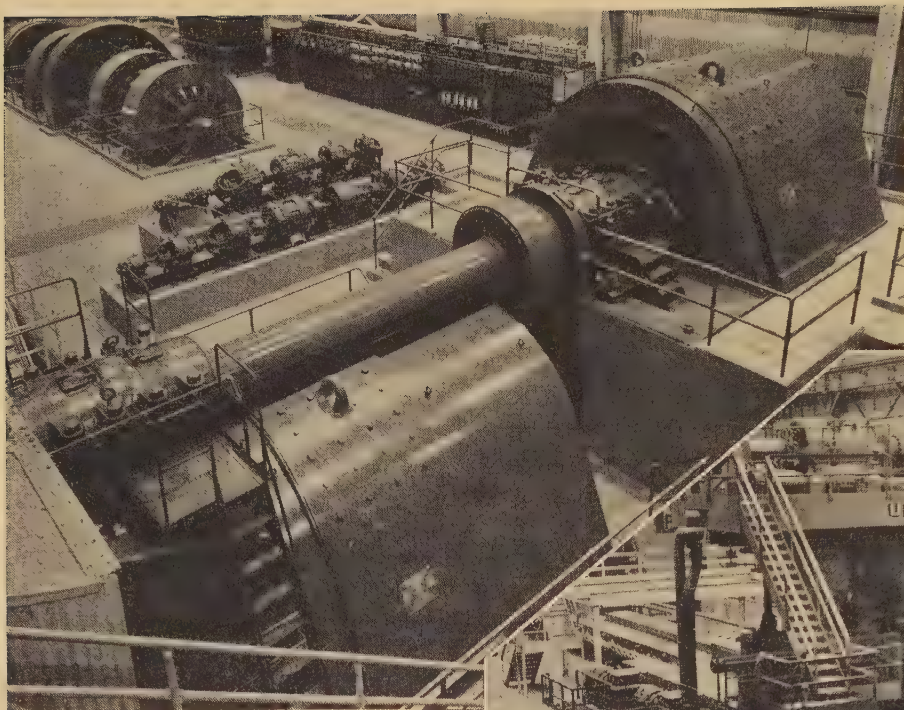


Figure 5 (above). Two 5,000-horsepower 40/80-rpm reversing motors driving main horizontal rolls of a 45- by 80-inch universal slabbing mill

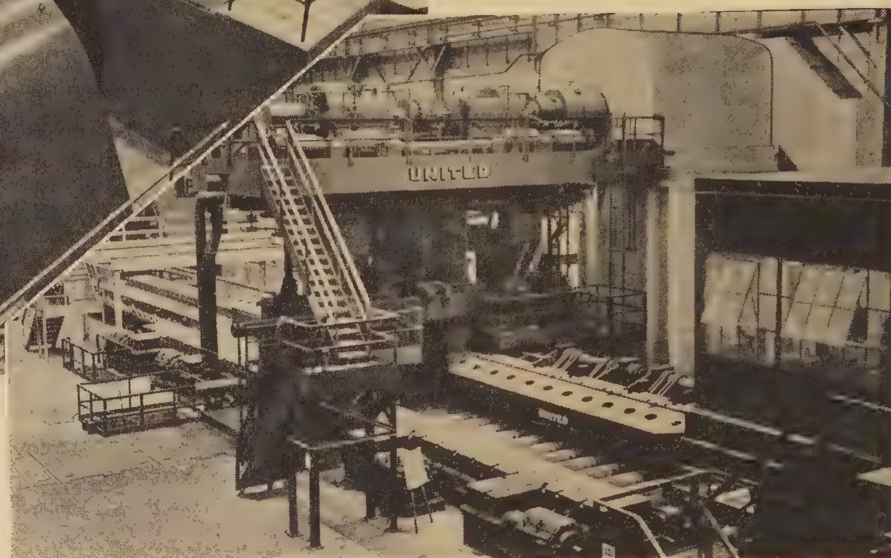


Figure 4 (below). Pulpit side of 45- by 80-inch universal slabbing mill

and a 900-horsepower synchronous driving motor, furnish the variable-voltage power supply to the screw-down table, manipulator rack, and shear motors of the mill described.

Reversing slabbing mills of the universal type, with both main horizontal rolls and auxiliary vertical edging rolls, have some decided advantages because of their ability to work on all four faces of the ingot without having to turn it, but they involve much more complicated and expensive mechanical and electrical equipment and hence are justified only where extremely large outputs of wide slabs are required. Also until recently the arrangement and drive of the vertical rolls limited the edging work that could be done, thus requiring a large number of ingot sizes, and the mill was quite inaccessible, making it difficult and time-consuming to change the vertical rolls or make other adjustments and repairs.

The 45- by 80-inch universal slabbing mill recently installed at a steel plant in the Pittsburgh district overcomes many of the difficulties inherent in earlier mills. Figure 4 shows the pulpit side of the mill, and indicates the arrangement of the drive for the vertical edging rolls. A 3,000-horsepower 60/180-rpm edging-roll motor is located in the mill building on a steel-and-concrete supporting structure about 25 feet high. The motor is coupled to separate spur-and-bevel-gear sets located at the top of the mill housing, and connections to the vertical rolls are by means of specially designed spindles. This arrangement provides much greater strength than earlier designs where the bevel gears were mounted directly on the vertical rolls, enables greater power to be transmitted to the vertical rolls, and also facilitates roll changing. Vertical edging rolls are 36 inches in diameter, and the main horizontal rolls are 45 inches in diameter by 80 inches long. The upper horizontal roll may be lifted 66 inches maximum to facilitate heavy reductions on the first two passes to crack the scale with the ingot on edge, after which the ingot is turned on its side for the remaining flat passes. Ingots range up to 32 by 66 inches, 45,000 pounds in weight, and are rolled into slabs up to 60 inches wide.

Each of the main horizontal rolls is driven separately by a 5,000-horsepower 40/80-rpm 700-volt d-c reversing motor, the two motors comprising a 10,000-horsepower twin-motor drive (figure 5). The 13,000-horsepower combined capacity of the main- and edging-roll motors is the largest power ever applied to a single mill stand. The twin-motor drive for large reversing mills, eliminating the usual pinion stand, was developed by Westinghouse about ten years ago, and two 10,000-horsepower installations were made in 1929 and 1930 for driving a 54-inch blooming mill and 44-inch slabbing mill, both at the South Chicago plant of the Carnegie-Illinois Steel Corporation. Each of the 5,000-horsepower motors for the original drives was built as a double-armature unit, in order to reduce frame diameter and keep the distance between the upper and lower motor shafts to a minimum. In the latest design for the Pittsburgh slabbing-mill drive the 5,000-horsepower rating of each motor is developed in a single unit, which is more efficient than the double-unit machines, and which can be built with only slightly greater distance between the upper and lower motor shafts.

## Hot-Strip Mills

Most of the recently installed continuous hot-strip mills have conformed in general arrangement to a fairly well standardized design, and variations have been in details rather than in the general arrangements of the roll stands and principal auxiliaries. The roughing train usually consists of four main mill stands, together with an auxiliary scale-breaking stand preceding the first stand and vertical edging mills proceding each of the other three roughing stands. The finishing train consists of six main mill stands, together with one auxiliary scale-breaking stand. In the roughing train the steel slab or bar is relatively short and the stands are spaced well apart, so that the bar is in only one main stand at one time, and these stands therefore can be driven by constant-speed a-c induction or synchronous motors. In the finishing train the bar has been greatly elongated, and the stands are spaced as closely as possible, so that the bar may be in several or all of the finishing stands at one time. These stands therefore must be driven by d-c adjustable-speed motors to be able to match the relative speeds properly, and to avoid looping or stretching the strip between stands. Figure 6 is a view of a typical continuous hot-strip mill, showing the closely spaced finishing stands in the foreground and the roughing stands and slab-reheating furnaces in the background. The motor room of a modern 56-inch mill is shown from the finishing end in figure 7. Finishing stands are driven by six 3,000-horsepower d-c adjustable-speed motors operating at 600 volts. Power is supplied to them by two 6,000-kw motor generator sets shown along the left wall in the illustration.

Large 80- to 98-inch mills have main drive motors totaling from 40,000 to 43,000 horsepower.

Earlier hot-strip mills were arranged to handle only comparatively short slabs, and the roughing stands were geared to operate at quite high rolling speeds, so that the duration of the roughing passes was only a few seconds and the peak loads were very high as compared with the average load. Under such conditions these roughing stands were equipped with flywheels to equalize the peak loads and were most satisfactorily driven by wound-rotor induction motors. In more recent mills the rolling speeds of stands 1, 2, and 3 usually are much slower; also the trend is toward the rolling of longer slabs in order to secure as long a strip as possible in one piece. Thus the duration of the roughing passes now may be 15 seconds or longer, and the peak loads are reduced because of the slower rolling speed. Flywheels are of little value where the load persists for more than six or eight seconds, and synchronous motors, therefore, may be successfully applied. One 56-inch and one 44-inch mill each have all four roughing stands driven by synchronous motors, and synchronous motors also have been applied successfully to one or more of the roughing stands of several 56-, 66-, 77-, and 80-inch mills. Synchronous motors have advantages of higher efficiency and lower first cost, and by proper control they may be used for power factor and voltage control.

The d-c finishing-stand and scale-breaker motors on a large hot-strip mill may total 25,000 horsepower and be supplied from generators totaling 18,000 kw, this entire capacity being concentrated on a 600-volt d-c bus not much longer than 100 feet. In the event of a failure at any point in this compact system, the short-circuit current easily may be 250,000 amperes or more, and special air circuit breakers and bus arrangements have had to be developed to withstand stresses developed during such abnormal current flow. Figure 8 shows a 6,000-ampere 750-volt single-pole heavy-duty air circuit breaker of the type developed for this service. Main and arcing contacts are arranged so that flow of current through the breaker tends to increase the contact pressure and thus prevent burning of the contacts before the breaker is unlatched. Extremely rapid opening is secured by means of heavy springs and the blowout effect of the current flow; the shock of opening is absorbed by a combination of pneumatic and rubber bumpers. The various parts are assembled on two rigid insulated steel posts. Normally the breaker is of the pedestal type for floor mounting, although it can be arranged for panel mounting when necessary.

A composite section across the finishing end of the motor room for a 56-inch strip mill installed during 1939 is shown in figure 9, which indicates relative locations of power-supply generators, finishing-mill motors, circuit breakers, and busses. The motor room is only 60 feet,

Figure 6. A 76-inch continuous hot-strip mill

4 inches wide, restricting the space between the motor and motor generator foundations for the finishing-mill d-c control equipment to about 13 feet, 3 inches. Main busses, therefore, are located inside the foundations underneath the motors and motor generator sets, in order to place the air circuit breakers closer to foundation walls and provide adequate passageway between breakers. This arrangement also gives greater accessibility to the motor dynamic-braking control panels, generator-field and master-control panels, and motor-operated rheostats, which are mounted along the foundation walls between the main circuit breakers.

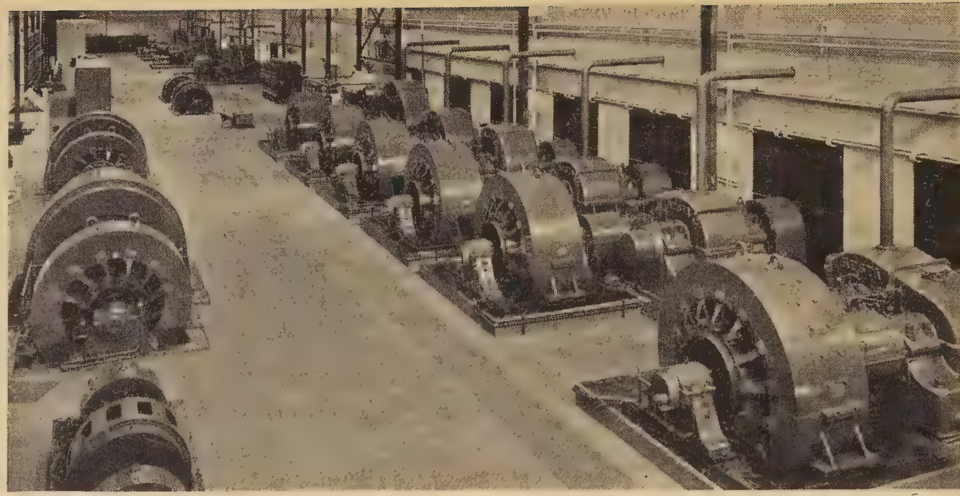


**Figure 7. View of the motor room of a modern 56-inch continuous hot-strip mill from the finishing end**

Operation of the many large electrical machines in a relatively small motor room results in large heat losses, necessitating circulation of extremely large volumes of ventilating air to dissipate the losses and keep the machines and motor room at reasonable temperature. In some instances filtered air is blown up through the machines and into the motor room from which it is discharged through roof ventilators or other openings. However, air filters require a great deal of maintenance and are only partially effective in removing dirt, so that much dirt is blown into the machines. The air is not cooled, and in warm weather the motor room may become uncomfortably warm for attendants. Many recent installations, therefore, have provided for cooling and recirculation of ventilating air, reducing the quantity of dirt carried into the machines, and maintaining more reasonable temperatures. In one 56-inch continuous hot-strip mill the machines are arranged with suitable enclosing covers so that the warm air from the machine is not thrown out into the room but is collected and discharged downward into the foundation pits. Warm air passes through the air coolers, which absorb heat and cool the air to a reasonable temperature, usually about 85 to 90 degrees Fahrenheit; then recirculating fans return the cooled air to the motor room where it again is drawn into the machines. A small makeup filter and fan are provided to compensate for leaks from the closed recirculating system and to keep the motor room under slight pressure so that external dirt will not sift in. In this particular mill each of the four air-recirculating fans is rated at 80,000 cubic feet per minute at a three-inch discharge pressure, requiring a 75-horsepower driving motor. Each of the four coolers is designed to absorb a 600-kw loss and to cool the air to 90 degrees Fahrenheit; each requires about 400 gallons per minute of cooling water at 75 degrees Fahrenheit. The air-makeup fan is rated at 25,000 cubic feet per minute. Additional coolers and recirculating fans are provided for the roughing-mill motors and auxiliary motor generator sets, and a second makeup filter and fan are provided at the roughing end of the motor room.

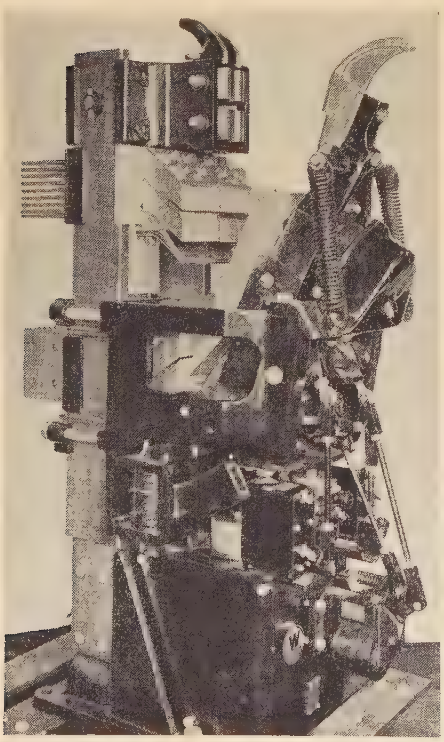


**Figure 8. Heavy-duty 6,000-ampere pedestal-mounted air circuit breaker**

## Cold-Strip Mills

The hot-strip mill ordinarily produces strip ranging from 0.050 to 0.125 inch thick. A part of this hot-mill output may be sold as hot-rolled strip or sheets, and in plants with older finishing mills the hot strip may be cut and further reduced to the required final gauge by hot rolling in sheet or tinplate mills. However in most modern installations the hot-strip mill is paralleled by cold-reduction strip mills, and a large proportion of the hot strip is cold reduced to the finished thickness. Cold-reduced strip for tinplate was first produced about ten years ago, and at present cold-reduction mills provide more than 55 per cent of the total tinplate capacity of United States plants.

Cold-strip mills may be classified as to type of mill, whether single-stand reversing or multistand tandem, and as to class of product, whether for wide, relatively heavy-

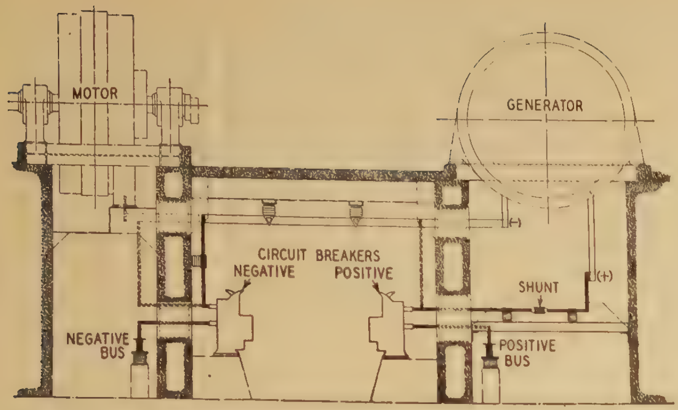



**Figure 9. Arrangement of air circuit breakers and main busses for strip-finishing control**

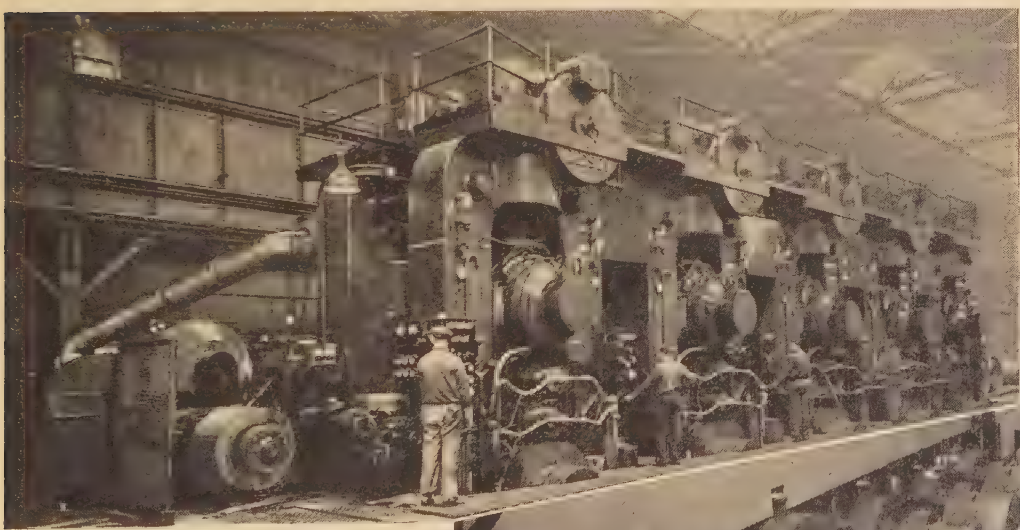
gauge sheets as required for automobile bodies and fenders, metal furniture, and refrigerator cabinets, or light-gauge narrow strip for tinplate.

Ordinary automobile sheets range from about 0.030 to 0.050 inch thick, and up to 80 inches wide and in usual practice may be cold rolled in about three passes from hot strip 0.080 to 0.125 inch thick. Strip for tinplate is 0.008 to 0.012 inch thick, 24 to 36 inches wide, and in usual practice requires about five cold-reduction passes to roll from hot strip 0.060 to 0.080 inch thick. Mills for tinplate therefore are relatively narrow—usually 42 inches—have four or five stands if they are of the tandem type, and run at speeds of 1,500 feet per minute or faster in order to provide the required output capacity of the light finished material. Mills producing sheet material may range up to 98 inches wide, consist of only three stands, and usually run at speeds of from 500 to 600 feet per minute.

A typical five-stand tandem cold-reduction 42-inch strip mill (figure 10) used for rolling light-gauge strip for tinplate, has stands spaced on 13-foot centers, with tension winding reel following the last stand. This mill and a second duplicate mill in the same plant were originally built to operate at a maximum rolling speed of 1,200 feet per minute, but have been changed to permit operation up to 1,500 feet per minute. On favorable schedules outputs of 40 net tons per hour are attained, and the two mills together can produce 30,000 tons or more per month. The main-drive electrical equipment (figure 11) has a 500-horsepower 600-volt d-c motor driving stand 1 and four 1,250-horsepower motors driving stands 2, 3, 4, and 5. The 250-horsepower winding reel is located in the mill building. Variable-voltage power for the mill and reel motors is supplied by a 5,000-kw synchronous motor generator set.

The largest mill yet installed is a 98-inch three-stand tandem mill (figure 12) capable of rolling strip up to 94 inches wide, such as required for automobile bodies and fenders and refrigerator cabinets. The mill is geared for a maximum rolling speed of 800 feet per minute. The number 1 mill is driven by a 1,500-horsepower 300/600-rpm 600-volt d-c motor; numbers 2 and 3 mill motors are each rated at 2,500 horsepower, 225/450 rpm; and the winding-reel motor 600 horsepower, 250/875 rpm. Variable-voltage power is supplied by a 6,000-kw synchronous motor generator set. The motors are located in the mill building without a protecting motor room, and are completely enclosed and ventilated by an air-cooling and recirculating ventilation system installed in the basement control room under the motors.

Tandem mills as just described have large production capacity, but require large capital investment and in some respects are not as flexible as single-stand reversible mills.



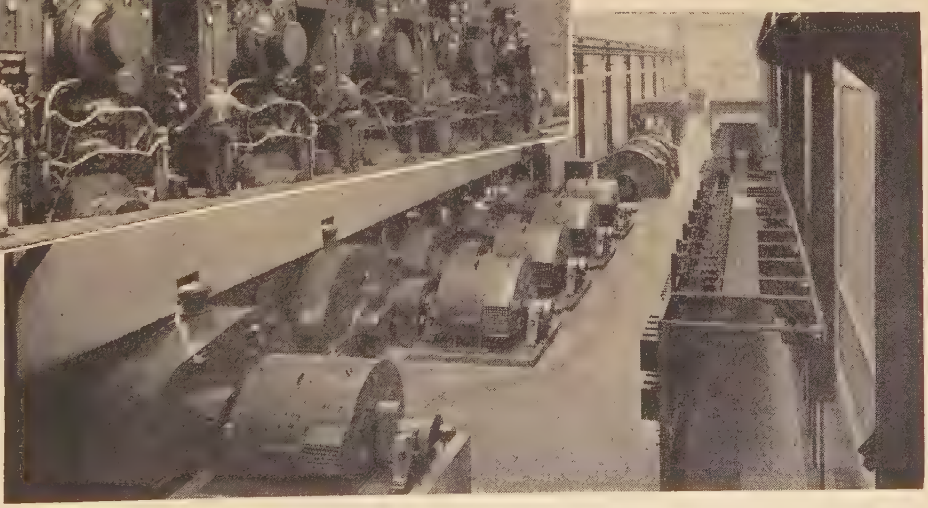


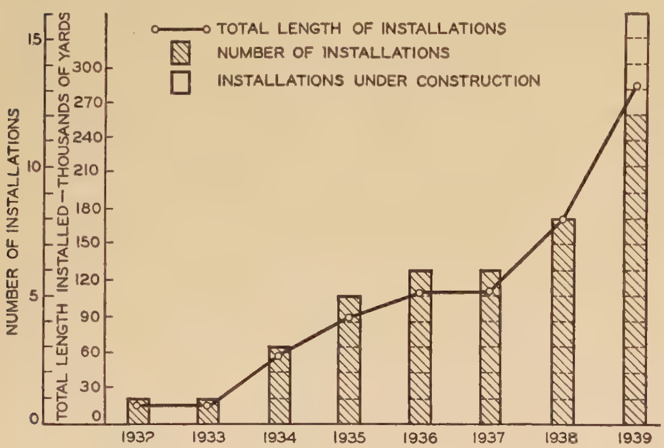
**Figure 11 (below). Motor room of a 42-inch tandem cold mill**

**Figure 10 (above). A 42-inch five-stand tandem cold-reduction strip mill for tinplate**

A reversible mill consists of a single mill stand with a tension reel on each side of the mill stand. Mill and reel drives are reversible so that the strip may be unwound from one reel, passed between the reducing rolls, and rewound on the second reel. The mill rolls then are screwed down and the operation reversed so that the strip is unwound from the second reel, passed back through the mill, and rewound on the first reel. This reversible process is continued for as many passes as are required to effect the required total reduction. The two reel motors are controlled so that they operate alternately as motor or generator. The machine driving the winding reel acts as a motor to supply part of the rolling power. The machine on the unwinding reel acts as a regenerative braking generator and exerts a back tension on the strip. Front and back tensions are independently adjustable under the operator's control. This type of mill is thus adaptable to varying operating conditions.

## Use of Pressure-Type Cable Increasing in Europe

AMERICAN engineers undoubtedly will be interested in some of the latest data and statistics on the use of a form of extra-high-voltage cable that has not yet been employed in America, namely, the pressure cable, which has been used in Europe since 1932 in increasing amounts.




The main problem in high-voltage paper-insulated cable is the prevention of voids during contraction cycles when load is reduced. In an oil-filled cable, voids are prevented by the flow of oil from reservoirs into the cable while it is cooling, through channels in the cable itself. In the pressure cable, the same result is accomplished by gas pressure external to the lead sheath. To assist the lead in undergoing this slight diaphragm action, the sheath is made either slightly triangular or oval in shape and reinforced with a bronze tape to prevent cumulative bending. In the original form as described by Hochstadter, Vogel, and Bowden in *Elektrotechnische Zeitschrift* in 1932, page 145, the cable is placed in a steel pipe filled with nitrogen under a pressure of about 15 atmospheres. The cable itself is either a three-conductor cable with a triangular sheath, or a three-conductor *SL* (separately leaded) cable with individual elliptical sheaths. In the latest developments in England, a reinforced lead sheath has been substituted for the steel pipe as a pressure restraining medium, this type being known as the self-contained pressure cable. The latter type was described by K. S. Wyatt (A'32) at the Conférence Internationale des Grands Réseaux Électriques á Haute Tension, Paris, 1939.

The accompanying tabulation shows the installations in service or under construction. Of these all are of the pipe type with the exception of the last two which are self-contained. The accompanying graph shows the growth in mileage of this type of pressure cable.

### Installations of Pressure-Type (Hochstadter) Cable

Pipe-Line and Self-Contained Types; Total Length About 288,000 Feet

| No. | Location | Kilovolts | Conductors: Number | Conductors: Cross Section (Circular Mils) | Conductors: Material | Insulation Thickness (Mils) | External Diameter of Cable (Inches) | Internal Diameter of Pipe (Inches) | Circuit Length (Feet) | Year Installed | Load (Kva) | Type of Construction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | London, England | 66 | 3 | 191,000 | Copper | 340 | 2.97 | 4.76 | 13,110 | 1932 | 31,500 | Pipe line |
| 2 | Muldenstein, Germany | 60 | 2 | 237,000 | Copper | 315 | 2.96 | 3.54 | 1,281 | 1934 | 22,000 | Pipe line |
| 3 | Copenhagen, Denmark | 55 | 3 | 187,000 | Copper | 236 | 2.68 | 3.15 | 43,200 | 1934 | 28,000 | Pipe line |
| 4 | Oslo, Norway | 66 | 3 | 295,000 | Copper | 276 | 3.27 | 3.94 | 10,320 | 1935 | 45,000 | Pipe line |
| 5 | Stettin, Germany | 110 | 3 | 237,000 | Copper | 473 | 4.1 | 4.93 | 24,810 | 1935 | 60,000 | Pipe line |
| 6 | Braunschweig, Germany | 50 | 3 | 295,000 | Aluminum | 236 | 2.84 | 3.54 | 17,550 | 1936 | 28,000 | Pipe line |
| 7 | Barmen, Germany | 50 | 3 | 237,000 | Aluminum | 236 | 2.84 | 3.54 | 56,400 | 1938 | 25,000 | Pipe line |
| 8 | Elberfeld, Germany | 50 | 3 | 295,000 | Aluminum | 236 | 3.07 | 3.54 | 5,340 | 1938–39 | 27,000 | Pipe line |
| 9 | Elberfeld, Germany | 50 | 3 | 295,000 | Aluminum | 236 | 3.07 | 3.54 | 9,180 | 1939 | 27,000 | Pipe line |
| 10 | Elberfeld, Germany | 50 | 3 | 187,000 | Copper | 236 | 2.72 | 3.15 | 13,710 | 1939 | 27,000 | Pipe line |
| 11 | Munchen, Germany | 100 | 2 | 474,000 | Aluminum | 473 | 4.21 | 4.93 | 17,700 | Being installed | 36,000 | Pipe line |
| 12 | Watenstett, Germany | 120 | 3 | 365,000 | Aluminum | 551 | 4.6 | 5.91 | 9,030 | | 60,000 | Pipe line |
| 13 | Magdeburg, Germany | 60 | 3 | 474,000 | Aluminum | 276 | 3.52 | 3.94 | 27,600 | Being manufactured | 40,500 | Pipe line |
| 14 | Braunschweig, No. 2 | 60 | 3 | 257,000 | Aluminum | 276 | 2.99 | 3.54 | 19,650 | | 32,000 | Pipe line |
| 15 | London, No. 2 | 66 | 3 | 191,000 | Copper | 285 Min. | 3.67 | | 13,110 | | 32,000 | Self-contained |
| 16 | Ferrybridge, England | 66 | 3 Single Cores | 636,000 | Copper | 285 Min. | 2.75 Approx. | | 450 | | 60,000 | |

# Electricity in Chemical Plants

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**Because many chemical plants require heat for process use, many opportunities exist for the development of combined heat and electric-power supply systems in these plants, which are among the largest industrial users of electricity. Special precautions must be observed in selecting electrical equipment for use in chemical plants, because of the prevalence of flammable or corrosive fumes.**

CHEMICAL PLANTS are among the largest industrial users of electric power and electric-power equipment today. Two of the chief engineering and economic problems arising in connection with the building of chemical plants are the layout of the power system and the selection of drives for the various pieces of apparatus. These factors are frequently primary considerations in determining the general location of chemical plants.

Chemical plants may be divided into two general classes regarding the electric-power supply:

1. Those in which the processes are dependent essentially upon electric supply.

2. Those in which the processes are dependent chiefly upon steam.

To the first class belong the electrochemical or electrometallurgical plants which carry on some electrolytic process, or else some heat reducing process only possible or commercially feasible at the high temperatures obtainable by electric heat, and which at the same time have few operations requiring low-temperature heat. This class of plant depends primarily upon low-price electric power and therefore is restricted to localities where power may be generated cheaply, such as near the coal fields or some large hydroelectric development.

To the second class belong the chemical plants that carry on some process in which the solution of chemicals or the evaporation of excess moisture requires relatively low temperatures such as may be obtained from steam. This class of plants is located with relation to raw materials, markets, labor, transportation facilities, supplies of fuel, and intermediate products. The cost of electric power, either generated or purchased is of secondary importance. Plants of this type are not confined to certain localities, but are distributed throughout the country; however, for other reasons they are somewhat concentrated in the eastern section of the United States.

Practically all modern chemical equipment in the second class of plants must be driven and is, therefore, power consuming. Electric power and steam heat frequently go hand in hand in many industrial processes. A list of the processes requiring electric power and heat and the interrelation of processes for various industries is given in table I.

## Relation of Steam Heat and Electric Power

Steam is of essential value in the process industry. Amount, pressure, and temperature of steam used vary widely even among the same processes carried on by different manufacturers. In general, so far as the low-temperature heating operations are concerned, steam is the most economical medium to employ. In plants that require process steam in large and fairly constant quantities, many opportunities exist for the development of inexpensive power services.

Through the use of high-pressure boilers and pressure-reducing prime movers, the process steam required may be obtained, either as bled steam or high-pressure exhaust steam, while at the same time considerable quantities of electric energy can be produced very cheaply—sometimes for as low as two mills per kilowatt. A most interesting problem develops in the process industry by permitting the extraction of steam for electric-power generation from the steam generated by high-pressure superheating boilers before the steam is turned over at process pressure to the chemical processes. In the past, there was a tendency to treat the problems of an industrial power plant the same as those of a public-utility plant. Both have much in common, but because the industrial power plant must be necessarily considerably smaller than a public-utility plant and, therefore, less efficient, it is amiss to assume that purchased power will be cheaper. This might be true if the supply of power did not have connected with it the supply of heat. The supply of steam and electric power to a process is not two problems, but a combined single problem. The efficiencies of a public-utility power plant and an industrial power plant cannot be compared as a guide in determining which source will be most economical. The true criterion of a power plant's performance is the amount of heat put to useful work, or, in other words, the amount of preventable waste that can and should be avoided.

It is the primary business of public-utilities to sell power and services. It behooves them to render the best possible service without interruptions at the lowest possible costs within economic reason. The problems of an industrial power plant of the kind here being discussed are peculiar. The "by-product" power is incidental to furnishing heat. "By-product" power from pressure differences is in no way related to power from waste fuel, from the waste heat of process combustion, or from waste exhaust steam condensed through turbines. It is limited to that power which an industry can produce by generating steam at pressures within present ranges of practice and

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## Table I. Interrelation of Processes in Chemical Plants

| Process Industries | Unit Processes | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Absorption | Agitating & Mixing | Centrifuging | Chemical Processes | Crushing & Grinding | Dissolving & Leeching | Distillation | Drying | Dust & Fume Handling | Evaporation | Extraction | Filtration | Gas & Air Handling | Heat Technology | Liquid Transferring | Material Handling | Pressing—Hydraulic | Refrigerating | Sifting & Screening | Solvent Recovery | Thickening | Weighing |
| Cement & Lime | | ● | | ● | ● | | | ● | ● | | | | ● | ● | ● | ● | | | ● | | ● | ● |
| Ceramics & Glass | | ● | | ● | ● | | | ● | ● | | | ● | ● | ● | ● | ● | ● | | ● | | ● | ● |
| Chemicals | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● |
| Coal Products | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Electrochemical Products | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● |
| Explosives—Cellulose | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Fertilizers | | ● | ● | ● | ● | ● | | ● | ● | ● | | | ● | ● | ● | ● | ● | | ● | | | ● |
| Glue & Gelatine | | ● | | ● | ● | ● | | ● | | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● |
| Leather Tanning | | ● | | ● | ● | ● | | ● | ● | | | | ● | ● | ● | ● | ● | ● | ● | | ● | ● |
| Paint & Varnish | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | | | ● | | ● | ● |
| Petroleum Refining | ● | ● | ● | ● | | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● |
| Pulp & Paper | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● |
| Rayon-Cellulose & Acetate | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● |
| Rubber | ● | ● | | ● | ● | ● | | ● | ● | | | | ● | ● | ● | ● | ● | | ● | | | ● |
| Soap | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● |
| Sugar Refining | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | ● | | ● | ● |

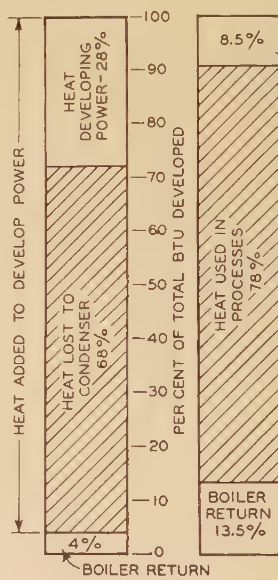
then passing this steam through a turbine or engine and exhausting it at a pressure high enough to supply a definite process requirement for heat deliverable as steam. The power plant of a process industry is more of a heating plant than a power plant; the problems are heat-engineering problems rather than power problems. It is only necessary to determine what degree of perfection is warranted to secure the best possible economy for one industrial plant, rather than for a group of industries as the central station must necessarily supply. The balancing of the quality of power service against its cost is of fundamental importance in the process industries. These are the greatest differences between an industrial power plant and a power plant, the single purpose of which is to produce power. A misunderstanding of the heat-power problem is a barrier to potential savings.

Wherein does the economy of "by-product" power generation lie? It is not difficult to prove that, in general, "by-product" is the cheapest power available to an industrial plant, providing operating conditions requiring electric power and steam heat are favorably balanced. In the typical steam plant there are three general steps:

1. Heat stored in fuel is delivered to a plant.
2. The fuel is burned and the stored heat is liberated and transferred to water and steam in the boilers.
3. The accumulation of heat in the boilers is transferred into electric power by a turbogenerator or an engine-generator set, or it is carried by the water and steam to the various processes.

If there were no waste of heat and the boilers, turbines, and generators were 100 per cent efficient, a quantity of fuel containing 3,412 Btu could generate one kilowatt-hour. It is impossible, however, to transform all of a given amount of heat supplied to a working substance into work. Modern boiler units operate at efficiencies of 80 to 85 per cent, the latter figure not being unusual; turbines operate at 95 to 98 per cent efficiency; and generators, 90 to 96 per cent. With these efficiencies, it is possible to produce one kilowatt-hour of "by-product" power at a fuel consumption rate equivalent to 4,300 to 5,000 Btu per kilowatt-hour, or 0.3 to 0.4 pound of average coal. The heat that cannot be transformed into work and

Throttle steam for both condensing-turbine and by-product generation is at 400 pounds gauge pressure and 200 degrees Fahrenheit superheat. Condenser turbine exhausts to a 29-inch vacuum. "By-product" generation exhausts at 80 pounds back pressure and 60 degrees Fahrenheit superheat. If the heat content of one pound of throttle steam is 1,330 Btu, the mechanical efficiency 97 per cent, the electrical efficiency 96 per cent, and all items are the same for each turbine, then the following is a comparison of the two systems:




**Condensing Plant**

Pounds steam per kilowatt-hour at turbine throttle $= \dfrac{3{,}412}{0.28 \times 0.97 \times 0.96 \times 1{,}330} = 9.8$

Btu per kilowatt-hour at turbine throttle $= 9.8[1{,}330(0.28+0.68)] = 12{,}800$

**"By-Product" Plant**

Pounds steam per kilowatt-hour at turbine throttle $= \dfrac{3{,}412}{0.085 \times 0.97 \times 0.96 \times 1{,}330} = 32.8$

Btu per kilowatt-hour at turbine throttle $= 32.8 \times 0.084 \times 1{,}330 = 3{,}660$

**Figure 1. Proportion of heat used in condenser-turbine (left) and "by-product" (right) power generation**

that must be rejected by the turbine can be used in the processes. In the central-station plant, the heat exhausted from the turbine is practically useless because of its low temperature and lack of pressure; such a condensing plant, even when operating at 1,400 pounds steam pressure and employing both the generative and reheat cycles must have a fuel consumption equivalent to 11,000 to 14,000 Btu per kilowatt-hour, or 0.8 to 1.0 pound of average coal.

In the "by-product" power plant, the heat may be extracted from a noncondensing unit at any desired pressure and temperature (this, of course, depends upon the initial pressure and temperature) and put to practical uses in the process. Temperature difference is necessary for heat transfer, and pressure difference is necessary for steam velocity in the unloading stages of the turbine to the processes. For this reason, considerably less power will be produced in the "by-product" plant than in the central station for the same fuel consumption, but the proportion of heat usefully applied in "by-product" generation to central-station generation is about in the ratio of three to one. "By-product" energy need be charged only for the heat actually used in passing through the turbine. This is not true for a central station because in a condensing steam turbine the heat of vaporization of the steam at the exhaust pressure is an unusable end-product that must be carried away by the condenser circulating water.

In the matter of selecting turbines for a plant, no general statement can be made because the conditions of every problem are different. However, in general, the following is correct:

1. Where the electrical load is predominant, the turbine should be a condensing-extraction type.

2. Where the steam load is predominant, the turbine should be a noncondensing-extraction type.

3. Where the steam demand balances the electrical demand, the turbine should be a straight noncondensing type. This type is seldom used because the balanced conditions are seldom obtained; however, the noncondensing turbine may be used in conjunction with a condensing turbine, and the steam may then be bled off the noncondensing turbine at process pressure. If the quantity of steam bled off is not all required for the process, it may be passed through the lower stages of the condensing turbine and used to produce power.

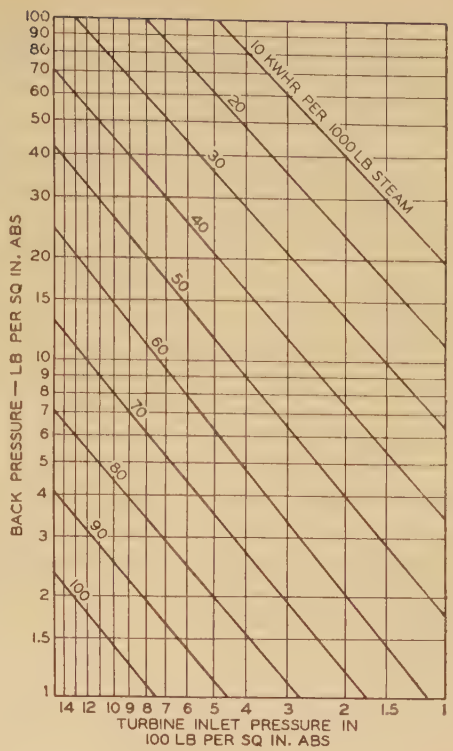
Figure 1 shows the magnitude of the heat quantities in the steam cycle of a condensing plant and of a "by-product" plant. As shown in the figure, a larger quantity of steam is required to develop a kilowatt-hour with "by-product" generation, but the heat energy (Btu) chargeable to power is considerably less than that required by condensing-turbine generation. The percentages given are for a specific problem, but indicate relative proportions of uses of the generated steam.

Figure 2 gives the power available from steam-process reductions for process use at various turbine inlet pressures and various extraction pressures. This chart is valuable for making preliminary estimates of power possibilities.

There are many schemes of connecting equipment and apparatus for the generation of by-product power from steam used later for process and heating. Figure 3 shows an arrangement of a turbine expanding some steam from boiler pressure to a process bleed point and the remainder passing through the lower stages of the turbine to the condenser. Figure 4 shows an arrangement using high-pressure boilers which supply two high-pressure turbines; one high-pressure turbine exhausts to a low-pressure condensing turbine and the second to an evaporator supplying the process steam.

Commercial development of high-pressure steam (1,000 pounds and above) has opened a field of unlimited possibilities in the direct application to chemical processes, but possibly greater possibilities in the field of power generation from steam later bled off or exhausted for process use at moderate pressures.

An approach to the application of steam for both by-product generation and process use would be for the chemical engineers, who are familiar with the process requirements, to set the process pressure or pressures as low as possible for economical production and compile daily load curves for process steam and power demand. In the




Graph is laid out for 100-per cent turbine efficiency so that conversion may be direct for substantial quantities. Actual yield in power may be taken at 70 per cent of that for the ranges plotted. Pressures are shown in pounds absolute (14.7 pounds higher than plus gauge pressures). Following vertically from any generated pressure and horizontally from any exhaust or process pressure, the axis will intersect at a value indicating the kilowatt-hours that would be produced by passing 1,000 pounds of steam from the generated pressure to the pressure used in the process. These values are plotted for a fixed superheat of 150 degrees Fahrenheit above the temperature at the generated pressure. Superheat variation has a very marked effect on the available power. The graph, however, is useful for preliminary estimates of power possibilities, as the curves permit approximation from figures on steam-pressure drop

**Example:** Dissimilarity of conditions will produce identical yields in power per unit weight of steam passed. On the curve for 40 kilowatt-hours per 1,000 pounds, note that this power will be produced by from 375 pounds to absolute, and also the same production is possible from passing from 1,200 pounds to 55 pounds. "By-product" power from pressure differences is practical only when the differences are effectively great as shown by the curves, and when the quantities of steam are substantial and continuously used

**Figure 2. Power available from steam-process reductions for process use**

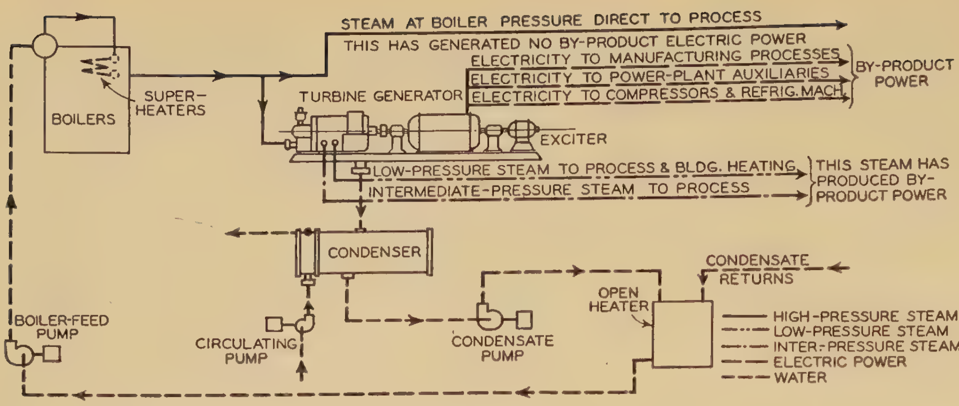



**Figure 3. Schematic arrangement of "by-product" power supply**

design of plants to supply process steam and power simultaneously this factor of relative amounts of process heat and power required is one of considerable economic influence. For each particular plant, this ratio of steam requirements to power requirements has certain determinable limits. The power engineer by proper consideration of these limitations with other economic conditions could assume an initial pressure and plot from the process-demand curve, a curve of the by-product power available. The latter curve then could be compared with the power requirements and if found insufficient at all hours during the day the boiler pressure may be increased, or the temperature of the steam generated may be increased without a change in pressure, or both the temperature and pressure of the turbine-throttle steam may be changed, until the electric power made available by by-product generation would balance that needed. The most effective way of all to increase the power output is to decrease the exhaust pressure.

In actual practice, it may be more economical not to carry the pressure to a point where all the power required can be generated as a by-product of process steam. The propinquity of a central station and a connection with a utility system is a good thing as a stand-by and to take peak loads in excess of power generated. Unfortunately, utility companies by their demand charges under stand-by conditions tend to make such connections unprofitable.

If power is purchased, the demand charge may range from 20 per cent to as high as 75 per cent of the amount of the power bill. The sum total of all the current demands of the processes constitutes the maximum demand on the electric company's power plant. But, of course, all these maximum demands never will occur at the same time, so the load factor, or ratio of actual consumption to maximum demand is only a part of the maximum demand that the power house must be prepared to meet.

Figure 5 shows a load curve for a plant having peak demands. The average load is much smaller than the maximum demand; the load factor is low and the power company, in order to make a profit on their business, must charge a high rate for the low load factor.

Figure 6 shows a load curve for a plant having an even demand. The load runs fairly even and the average load and maximum demand are nearly equal, resulting in a high load factor. The cost per unit for current would be lower for the same total kilowatt-hours than in the first plant.

Knowledge of what maximum demand and load factor means can be applied so that money may be saved on the power bill through the reduction of maximum demands. The heavy power-consuming processes should be scheduled so that the peaks for the various processes would not occur at the same time, and by overlapping the operating periods the maximum demands would be reduced. Reduction of the maximum demand will result in a reduction of power cost for the same power consumption.

## Selection of Electrical Equipment

Rarely are electric motors subjected to more severe services than under the dusty, corrosive conditions found in most chemical plants. As regards the selection of motors and motor-control equipment, the chemical industry may be divided into three groups involving:

1. Fire or explosion hazards.
2. Heat-damage hazards from high temperatures.
3. Corrosion hazards from acid and alkali fumes and from vapors and excessive moisture.

Fire and explosion hazards are encountered in the handling of materials in certain chemical-engineering industries. Electrical equipment and static electricity are the

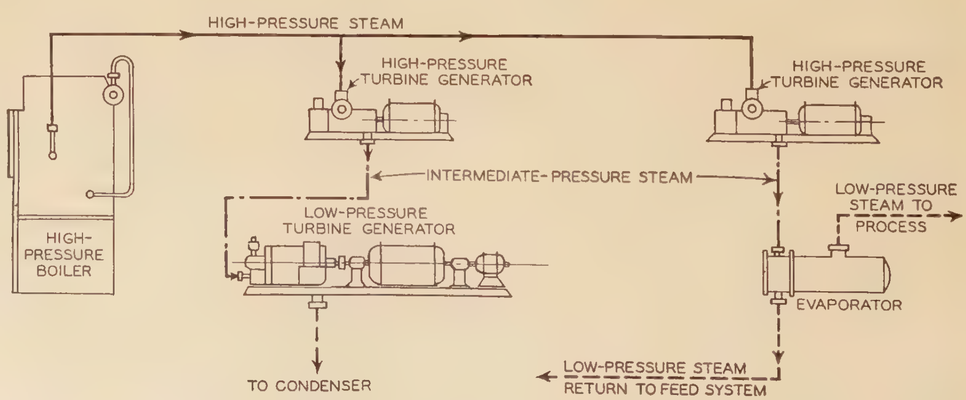



**Figure 4. Schematic arrangement of "by-product" power supply using high-pressure boilers and turbines**

usual sources of such hazards. Static electricity of high voltage can be generated by transmission belting and may ignite chemical fumes. Static charges may be built up in one or all of three ways: by the separation of the belt from the pulley, the friction of the belt on the pulley, and the friction of the atmosphere on the belt. The principal source of static charge is the separation of belt from the pulley. Charges are generated on both the pulley and the belt under certain conditions. Whenever two dissimilar materials that have been in contact are separated, a static charge results.

Motors, pulleys, and shafting can be grounded, but the belt, usually a nonconductor, allows the potential to build up under some circumstances until sparking occurs; this is sometimes the cause of mysterious fires and explosions occurring in the handling of volatile solvents. An effective means for the prevention of static on belts is as follows: A wooden frame supported from the ceiling or overhead beam has attached to it a piece, or pieces, of ordinary copper screen wire that is held in contact with the moving belt and grounded by means of copper wires connecting with the sprinkler system or water main. The screen wire is sufficiently flexible to maintain a continuous contact with the belt without exerting a pressure that would cause excessive wear.

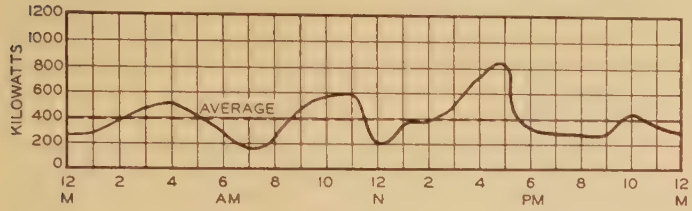



**Figure 5. Load curve for plant having uneven demand**

Averge load is much less than maximum demand; hence load factor for this plant is low

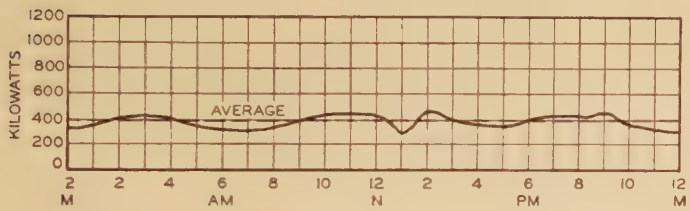



**Figure 6. Load curve for plant having even demand**

Average load and maximum demand are nearly the same; hence load factor for this plant is high

As the result of recent investigations by some prominent manufacturers, it has been found that charges on the driving belts can be dissipated by treating the belts with an aqueous dispersion of colloidal graphite. This electric furnace product is a good conductor of electricity, and the graphite films formed in the belts carry static charges from the pulleys to the frames of the machines.

The dangers of static electricity from belting in the presence of flammable vapors and also the inability of this medium of transmission to give the required accuracy of speed with certain types of apparatus has brought about the development of such power transmission methods as the reduction gear units directly connected to the motors.

The majority of industrial chemical equipment is operated under what is known as the "closed system," but regardless of this precaution flammable and explosive vapors are at times present in the areas surrounding and adjacent to the apparatus. The motors and control equipment should also be operated as a closed system. The motors driving the equipment may be placed in a sealed space or in an adjacent room. If they are located in the same area as the equipment, they should be of the totally enclosed fan-cooled type for fire-hazardous locations and of the explosion-tested type for certain explosion-hazardous locations. It has been found practically impossible to keep vapor, fumes, and some corrosive dusts out of dustproof control equipment, but immersing the control equipment in oil has given very satisfactory results.

If the ambient temperature is high, say above 40 degrees centigrade, motors having a 40-degree rise should be selected or ordinary motors derated about 20 per cent in output. If the ambient temperature is above 50 degrees centigrade, it might prove advisable to install pipe-ventilated motors drawing the cooling air from the outside.

For corrosive, hazardous locations, the equipment should be the same as for the "closed system" of operation. In addition the equipment should be protected with an acid- and alkali-resisting paint.

Synchronous motors can be used to good advantage in driving equipment for refrigeration and compressed-air service. This type of motor offers some power-factor correction. In the smaller industrial plants, when the auxiliary electric power is an appreciable part of the total generator capacity, it is very desirable to have the power-factor-correction capacity. Such a type should always be used if possible when power is purchased from a public utility, as it means lower monthly billings.

## Distribution System

The distribution system may be either aerial or underground. The aerial method is very much the cheaper where distances are in the order of 1,000 feet or more, but should never be considered where the industrial site is congested. If overhead, the usual method of distribution is by means of triple-braid weatherproof conductors on wooden poles or steel towers. If underground, then varnished-cambric lead-covered, or other suitable insulated, cables are used in fiber ducts encased in a concrete envelope.

If the industrial load is small, say less than 500 kva, and the distances of distribution not greater than 1,000 feet, the generated voltage can be 220 or 440 volts. On larger projects, it is preferable to generate at 2,300 volts or higher and the energy at this voltage is transmitted to small local outdoor or indoor substations and then further distributed at 220, 440, or 550 volts to the industrial loads; 2,300-volt motors may be supplied from the 2,300-volt bus in the substation by means of local switching. The higher voltage requires the use of oil circuit breakers at all points, while the lower voltage permits the use of carbon

breakers or safety switches in the power house and substations, and safety switches in the industrial buildings. The substations should be located as close to the center of distribution as possible.

## Metering

A minor but nevertheless important item in the supply of power services to the various processes or departments is that of metering. The power requirement for each department, building, process, or section of the manufacturing plant, together with the total for each service from its point of origin, should be metered. The sum of the individual loads should be balanced daily against the total generated output and any discrepancy corrected immediately. Any losses noted may be found more easily, increases in consumption by any division noted and explained, and controversies over service charges backed up with documentary evidence of actual consumption. Thus meters of the recording type are a worth-while investment because of their aid in detecting losses from the distribution system and in allocating equitably service costs for accounting purposes. The meter usually used for this purpose on feeder circuits is the kilowatt-hour meter. An ammeter for each circuit and a voltmeter for a group of circuits may be used in determining the power factor of the load. The feeder circuit and also the generator capacity are dependent on the ampere requirements and not upon the kilowatt load.

## Artificial Illumination

As regards artificial illumination, the chemical industry may be divided, just the same as with electric control equipment, into several groups involving:

1. Explosive material, fumes, or vapor.
2. Alkali fumes and vapors.
3. Acid fumes and vapors.
4. Excessive moisture.
5. Laboratory.
6. Yards.

The processes are usually self-making, requiring heat and time. The worker's duty is to watch gauges, indicators, and the like, and he does not perform careful visual work

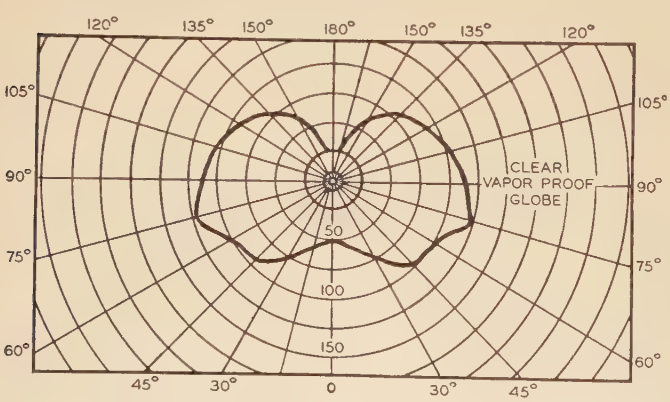



**Figure 7. Light-distribution curve for a lamp and clear-glass vaporproof globe**

as required in other kinds of plants. The lighting is, therefore, for safety and usually a low intensity is sufficient. Greater intensities should be obtained on gauges, thermometers, and valves by locating lighting units near these important points.

Selection of the proper type of reflecting and diffusing units is a most important item in illumination. Experience shows that the lighting intensities in many plants are far below what they should be for efficient work. The recommended levels of illumination for chemical works according to present-day standards are:

| | Foot-Candles |
|---|---|
| Hand furnaces, boiling tanks, stationary driers, stationary or gravity crystallizing | 5–7 |
| Mechanical furnaces, generators and stills, mechanical driers, evaporators, filtration, mechanical crystallizing, bleaching | 6–10 |
| Tanks for cooking, extractors, percolators, nitrators, electrolytic cells | 10–15 |
| Laboratory | 15–20 |

Vaporproof units employing the plain glass globe have been used most generally throughout chemical plants. This is a wasteful and an ineffective practice because the

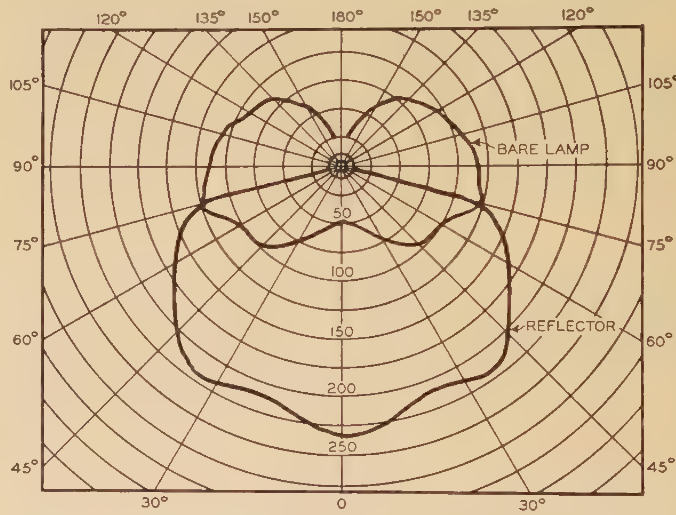



**Figure 8. Light-distribution curve showing how a porcelain-enameled steel reflector increases the effective candle power over that produced with the plain glass globe**

light is not directed in useful directions. The practice is comparable to the use of bare lamps in other industries—glare is pronounced and the uniformity of illumination poor. The distribution curve of a lamp and a clear glass vaporproof globe is shown in figure 7.

The simplest method of increasing the efficiency of the plain glass globe is to add a porcelain-enameled steel reflector (figure 8). Another method is to use one of the vaporproof prismatic reflector units. The distribution curves (figure 9) show how the light is reflected downward instead of being given off in nonuseful directions.

Where highly explosive fumes, material, or vapor are present, it is essential that all lighting equipment be absolutely tight not only between the globe and fitter or hood, but also between the sockets and conduit system. In some highly dangerous situations, the entire lighting

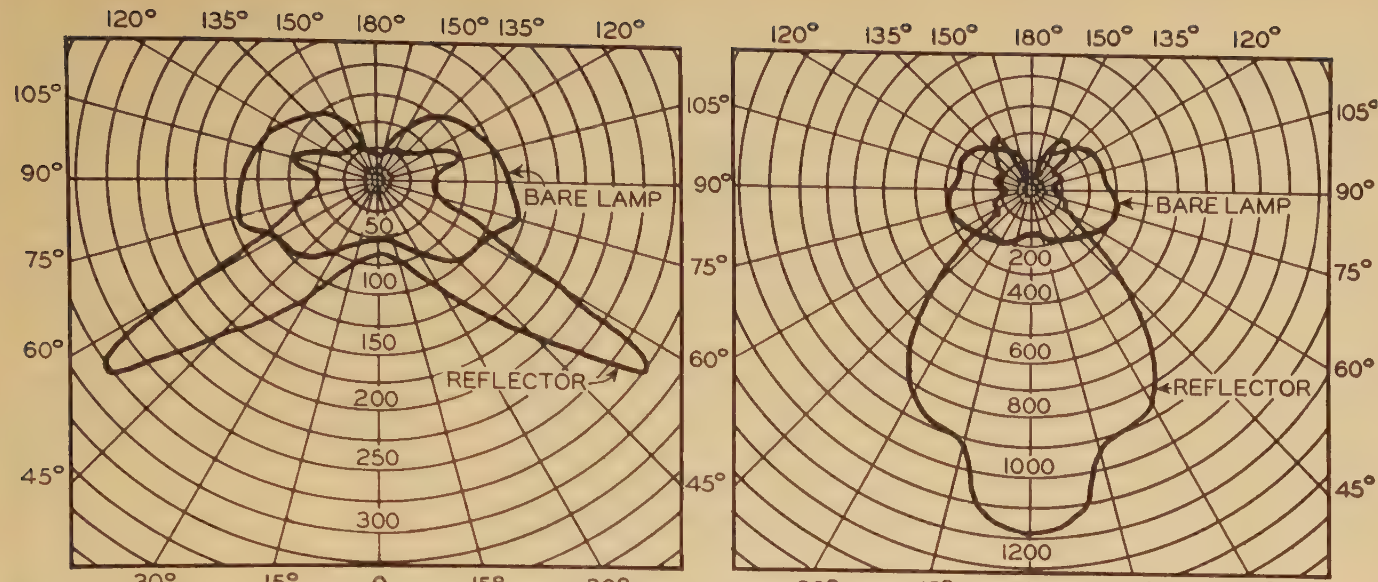


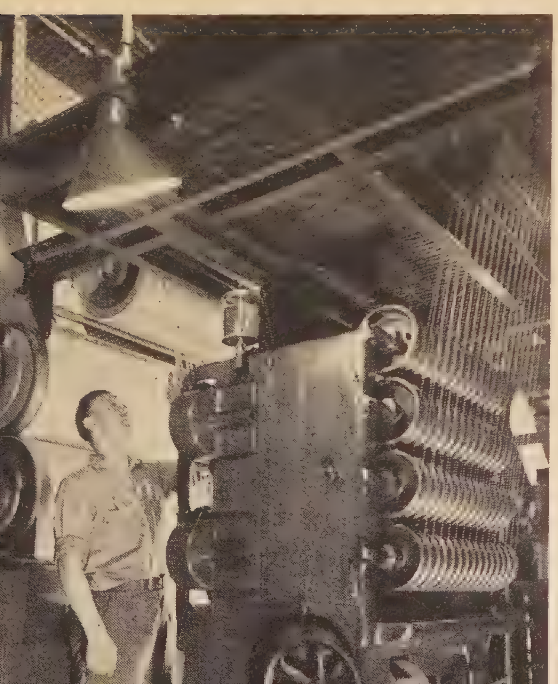

**Figure 9. Light distribution curves showing advantage to be gained by using vaporproof prismatic reflector globe instead of plain glass globe**

units are mounted outside the buildings and the light is transmitted into the rooms through glass windows. In other cases, where the flash point of the explosive substance is low, vacuum-type lamps in the smaller sizes (100 watts and under) are preferable to type *C* lamps in the larger sizes (100 watts and above). In order to make an absolutely tight fit between the globe and fitter or hood, gaskets are employed.

Fittings or hoods for use with vaporproof units are made of black or galvanized cast iron, silicon-aluminum alloy, or bronze. In general, where explosive material, acid, or excessive moisture are present, either the cast-iron with a black asphalt paint finish or the silicon-aluminum-alloy fittings are practical. Where alkali vapors are present, the galvanized cast-iron fitting is preferable; aluminum fittings should not be used. Where acid fumes are present, a fitter and globe that will withstand the action of acid should be employed. Cast-iron black asphalt-painted or silicon-aluminum-alloy fitters with a reflector or globe and reflector combination should be used. In some extreme acid conditions, lead alloy or Bakelite fittings may be used to advantage.

Wherever possible the illumination in the chemical laboratory should be of the indirect type using daylight lamps for the reason that the light should be well diffused without sharp shadows and should be of approximate daylight color so that the color of the various solutions and precipitates can be accurately judged.

Many chemical plants have extensive yards where pipe lines and passageways are present. In order that fire and accident hazards may be reduced to a minimum and that necessary work may be done in such yards and passageways, they should be lighted to a degree approximating eight times full moonlight intensity (0.2 foot-candle). The most suitable type of lighting unit for this service is a tightly enclosed prismatic reflector mounted on poles or brackets not less than 20 feet high. Spacing between adjacent units should not exceed eight times the mounting height



## New Telephone Cable Has 606 More Wires

WITHOUT increasing the diameter of its largest telephone cable from the former size of 2 $^5/_8$ inches, the Bell System has increased the number of separately insulated copper wires within the cable from 3,636 to 4,242. The diameter of the wires also remains unchanged. The addition of 303 pairs of wires within the same girth of cable was accomplished by an improved technique of insulation which reduced the thickness of insulation around each wire by 0.003 inch.

The method of insulation, which was invented within the last decade by Western Electric Company, consists of the application of paper pulp directly onto the wire, making a thin coating of paper. Formerly wires for cable had been insulated by wrapping paper ribbon spirally around them. The paper-pulp insulating machine is shown in the illustration.

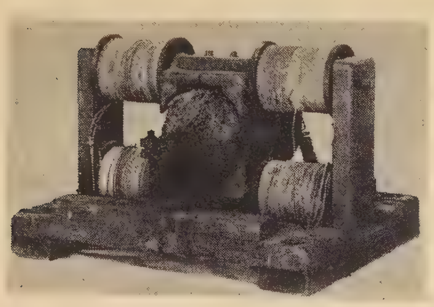
# Of Current Interest

## Honors

### Thomson's Early Work Commemorated in Philadelphia

A memorial tablet marking the site at which Elihu Thomson (A'84, F'13, HM'28) built his first bipolar dynamo for generating alternating current was unveiled in Philadelphia, Pa., January 3, 1940. Placed on the office building now occupying the site of the Harrison Machine Works where Thomson worked on inventions in 1878–79, the tablet was erected under sponsorship of the Franklin Institute and through the efforts of four of Thomson's early associates, A. L. Rohrer (A'87, M'88), J. R. Lovejoy (A'91, F'13), H. G. Reist (A'90, F'13), and W. J. Foster (A'07, F'16).

The Franklin Institute at the same time opened a display of Thomson's early inventions, including the original bipolar



dynamo, shown in the accompanying illustration, the shell-type transformers, and the vibrating-arc lamp, all developed before 1880.

## Education

**Iowa State Bulletin Reprints AIEE Paper.** The Engineering Experiment Station of Iowa State College issued as its bulletin 142, 1939, "Amplitudes of Magnetomotive-Force Harmonics for Fractional-Slot Windings of Three-Phase Machines" by J. F. Calvert (A'27, M'35). The theoretical development of this work, which was carried out as an experiment-station project, was presented at the AIEE summer convention, Washington, D. C., June 1938, and published in TRANSACTIONS (volume 57, p. 777–85, 1938) under the title "Amplitudes of Magnetomotive-Force Harmonics for Fractional-Slot Windings—I". Copies of the bulletin may be obtained without charge on request to the director of the Iowa Engineering Experiment Station, Ames.

**Broadcast Engineering Conference.** Sponsored by the department of electrical engineering of Ohio State University, with the co-operation of the National Association of Broadcasters, the third annual broadcast engineering conference will be held at Columbus, Ohio, February 12–23, 1940. Of particular interest will be a session on frequency modulation, and a trip by special train to inspect station WHAS, Louisville, Ky. The conference will also serve as an engineering convention for the National Association of Broadcasters. Further information about the conference may be obtained from Doctor W. L. Everitt, Ohio State University, Columbus.

**Engineering College at Duke.** The division of engineering at Duke University, Durham, N. C., formerly administered as part of Trinity College, has been reorganized by action of the trustees into the College of Engineering of Duke University. Curricula are offered in civil, mechanical, and electrical engineering. W. H. Hall, professor of civil engineering and chairman of the former engineering division, has been appointed dean of engineering.

## Other Societies

### ASA Reviews 1939 Activities at Annual Meeting

Work accomplished by the American Standards Association during 1939, as reviewed at the society's annual meeting, December 13, 1939, included completion of "American Standard Inspection Requirements for Motor Vehicles"; initiation of projects for standards on aeronautics and on photographic equipment; and continuation of work on co-ordinated building-code standards, merchandising standards for consumer goods, and prevention of occupational diseases. During the year 19 new standards and 45 revisions of previous standards were approved. Six groups, including professional societies, a government agency, and a trade group, affiliated with ASA in 1939, bringing its basic membership to 73.

Officers for 1940 were elected as follows:

*President*—E. A. Prentis, Spencer, White, and Prentis, New York, N. Y. (re-elected).

*Vice-president*—R. E. Zimmerman, United States Steel Corporation (re-elected).

*Chairman, Standards Council*—R. P. Anderson, American Petroleum Institute.

*Vice-chairman, Standards Council*—H. S. Osborne (A'10, F'21) American Telephone and Telegraph Company.

### *Future Meetings of Other Societies*

**American Chemical Society.** Annual meeting, April 8–12, 1940, Cincinnati, Ohio.

**American Institute of Chemical Engineers.** 32d semi-annual meeting, May 13–15, 1940, Buffalo, N.Y.

**American Physical Society.** 233d meeting, February 22–24, 1940, New York, N. Y.

234th meeting, April 25–27, 1940, Washington, D.C.

**American Society of Mechanical Engineers.** Spring meeting, May 1–3, 1940, Worcester, Mass.

**American Society for Testing Materials.** Committee week and spring meeting, March 4–8, 1940, Detroit, Mich.

**Association of Iron and Steel Engineers.** Annual Spring Conference, April 1–2, 1940, Cincinnati, Ohio.

**Electrochemical Society.** Spring meeting, April 24–27, 1940, Wernersville, Pa.

**ECPD Bibliographies.** A series of five bibliographies on engineering subjects have been prepared by the committee on professional training of the Engineers' Council for Professional Development. Developed in consultation with more than 100 teachers of technical and engineering subjects, the five individual lists are classified as: Section I, mathematics, mechanics, and physics; Section II, aeronautical and civil engineering; Section III, chemistry and chemical and industrial engineering; Section IV, electrical and mechanical engineering; Section V, metallurgy, mineralogy, geology, and mining engineering. Copies may be obtained for 10 cents a list, or 50 cents for the set, from ECPD, 29 West 39th Street, New York, N. Y.

## From AEC

ITEMS appearing under this heading are from the news service of American Engineering Council.

### American Engineering Council Holds 20th Annual Meeting

Representatives of the member engineering organizations of American Engineering Council met in Washington, D. C., January 11–12, 1940, for the 20th annual assembly of the joint organization. The program included reports of various committees, election of officers, and the annual All-Engineers Dinner, at which Doctor William T. Foster, director of the Pollak Foundation, Newton, Mass., was chief speaker. The 10th annual conference of engineering society secretaries was held concurrently.

In the annual report of the executive secretary, F. M. Feiker (M'34) summarized the work of AEC committees and staff and reported upon the plans under consideration for restating the objectives and reorganizing the work of AEC. (These activities and

other aspects of AEC action have been reported at various times in ELECTRICAL ENGINEERING.)

Election of officers took place at the annual business meeting, at which were present as AIEE representatives F. M. Farmer (A'02, F'13, president), C. O. Bickelhaupt (M'22, F'28), and National Secretary H. H. Henline (A'19, M'26) *alternate*. AEC officers for 1940 are: *president*, A. J. Hammond; *vice-presidents*, W. L. Bott, D. H. Sawyer, C. O. Bickelhaupt (M'22, F'28) and J. S. Dodds (last two re-elected); *treasurer*, L. J. Fletcher. F. M. Feiker resigned as executive secretary, effective July 1, 1940, to become dean of engineering at George Washington University; his successor has not yet been chosen. A biographical sketch of Mr. Feiker appears on page 89 of this issue.

## Power Capacity Growing

As of September 30, 1939, the installed capacity of all electric generating plants reporting to the Federal Power Commission aggregated 40,203,969 kilowatts, an increase of 1,161,864 kw, or 3 per cent, since December 31, 1938. Of the total, 85.7 per cent comprise generating stations owned by private utility companies serving the public, 11.6 per cent publicly owned plants, and 2.7 per cent those operated by railroads and other agencies not distributing to the public. Hydroelectric plants accounted for 11,353,925 kw; steam and internal combustion plants for 28,850,044 kw. Of the net increase, hydro totalled 287,862 kw, while steam and internal combustion units increased by 874,002 kw.

Recent major hydroelectric installations reported to the FPC consist of one privately owned 75,000-kw plant in Virginia and a 165,000-kw addition to the generating capacity at Boulder Dam. All other additions in the hydro class were in units of less than 25,000 kw. In steam generation, two private companies reported additions in excess of 50,000 kw, and a municipal plant installed an additional 30,000-kw unit.

# Industry • • • •

## Air-Conditioning Units for Home and Office Use

Three air-conditioning units designed for home and office use and priced for the consumer market have recently been developed by Westinghouse Electric and Manufacturing Company. The smallest of the three units, shown in the illustration, has a cooling capacity of 4,000 Btu per hour and is expected to be used chiefly in bedrooms. The next larger model, with a capacity of 6,000 Btu per hour, and total conditioned-air delivery of 225 cubic feet per minute, is planned for use in average private offices under the heavier requirements of daytime service. The largest of the line is a floor model for larger offices and private houses, with 8,500 Btu capacity and delivery of 300 cubic feet of conditioned air per minute.

The new units, called "Mobilaires," require no plumbing connections, only floor plugs, for installation. The window units may be installed without removing radiators and can serve as ventilators when cooling is unnecessary. Powered by hermetically sealed condensing units, they are as quiet in operation as a modern 16-inch electric fan, according to the manufacturers.

**Stone and Webster 50th Anniversary.** Founded in 1889 and still guided by Charles A. Stone (A'91, M'07) and Edwin S. Webster (A'91, M'07), two young electrical engineers who had graduated from Massachusetts Institute of Technology the previous year, the firm of Stone and Webster, Inc., celebrated its 50th anniversary during the closing week of 1939. Centering originally in the field of electric utility construction, the firm's work subsequently spread to embrace also financing and valuation work as well as the active operation and management of a variety of utility properties. The firm has been active from coast to coast.

**Another Air-Blast Breaker.** The first special demonstration of the new air-blast-type circuit breakers developed by Allis-Chalmers Manufacturing Company was recently given to a group of about 30 electrical engineers at the company's switchgear laboratory in Milwaukee, Wis. Following operating tests, the visitors examined the circuit breaker at close range. A demonstration of air-blast circuit breakers by General Electric Company at Schenectady, N. Y., was reported in the September 1939 issue.

**Television Handbook.** "Look and Listen" by M. B. Sleeper, a 96-page booklet covering the status of the television art and the design and construction of equipment, has been issued by The Norman W. Henley Company, 2 West 45th Street, New York, N. Y. Planned for both technician and lay reader, it contains general information as well as details of set building, installation, and servicing, and is illustrated. Copies may be obtained from the publisher, price, with spiral binding, $1.00; cloth, $1.50.

**Aluminum Company of America** announced December 24, 1939, that the company had contracted for 32,500 kw of Bonneville power ($500,000 annually) for 20 years, and expected to begin work soon on a $3,000,000 reduction plant just west of Vancouver, Wash.

# Letters to the Editor • • •

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

## Membership Participation in AIEE Elections

*To the Editor:*

Referring to President Farmer's communication in the November 1939 issue of ELECTRICAL ENGINEERING, concerning our election procedure, it is quite true that there has been a feeling that elections of officers are too much cut and dried in the AIEE with insufficient direct voice from the members.

The balloting is all set up in committees as explained in the article. This corresponds in a measure to the procedure in our national government, whereby national conventions nominate candidates. But with this difference—that in our government we have a party system of nomination and election, generally with one party in, and another party of the opposition, out.

In AIEE there is no set-up for an "opposition" party. This corresponds to conditions in totalitarian governments, where a person who disagrees with the party in power is just out of luck. Other large technical associations go about the matter of electing officers in just about the same way as we do in AIEE.

Representative government depends upon electing officers to govern on the basis that an elected group, small in numbers, is fitted to decide questions of state better than the mass of the voters. Recall, for not representing public opinion, is through subsequent elections by the efforts of an opposition party. This opposition party element, therefore, is ab-

solutely essential to our national form of government, without which we would become as Germany or Russia, and the party in power would perforce be self-perpetuating.

Except for the somewhat hazy provision for other candidates on the ticket, if proposed by 25 or more members, it would seem to be just about as well to let the presidents be elected by the nominating committee for all the difference it would make. If this nominating committee is truly representative of the membership, a direct popular vote would seem unnecessary. According to the United States Constitution, voters do not vote for the president and vice-president direct, but vote only for "electors," who in turn elect the President.

In national politics, parties represent either opposed controversial viewpoints or opposed personalities. In our AIEE, we do not have opposed policies but may have a choice of personalities.

The present method of setting up a "cut-and-dried" ticket and asking the members to vote in addition, is neither the representative method nor a bona fide direct election. It is largely responsible for the general feeling of dissatisfaction.

All of which leads to the suggestion that if a direct election by mail is continued, the nominating committees offer our members the choice of three candidates for the important offices with a statement outlining the history, affiliation, and previous activities on behalf of the AIEE. I say three, because if there were only two, a defeated candidate might feel unduly humiliated. The second in number of votes would be vice-president, etc.

I think that this method would at least be conducive to a more satisfied feeling on the part of many members. It would retain the best features of both the representative form and the direct form of elections.

Paul MacGahan (A'02, M'15)

(Development engineer, meter department, Westinghouse Electric and Manufacturing Company, Newark, N. J.)

## Specific Articles on Social Questions

*To the Editor:*

During the last few years Electrical Engineering has published a number of articles on the social side of engineering. These have all been interesting and informative, but I should like to see them go one step further. Why not go from the general to the specific? There are many social questions today the ultimate outcome of which will profoundly affect engineering in almost every phase. While the general press has not hesitated to print anything on the subject, even to the point of preferring sensationalism to veracity, the technical press has been content either to ignore the problem entirely or at best to deal only in generalities.

I should like to see a full, frank discussion of such things as the present social-security legislation, public-utility regulation, profit-sharing systems, labor organization, etc., particularly in their relation to the profession. While it may be difficult to get one individual to present an unbiased opinion on any of these subjects, it should be possible to find competent engineers on all sides of these issues. A symposium every few months on one of these controversial subjects would be of value and interest to the membership.

I am sure that everyone realizes the problems involved in trying to present an impartial view on such topics and will make due allowances if some of the articles do not coincide with their own opinions.

Of course the AIEE should not take sides on any of these issues, but it seems to me it is one of the functions (although only a minor one) of an engineering publication to keep abreast of social developments.

Daniel E. Robb (A'39)

(Aircraft radio laboratory, Wright Field, Dayton, Ohio)

## Currents and Voltages of a Three-Phase Unbalanced Load

*To the Editor:*

In the computation of the phase voltages and currents of an unbalanced three-phase wye load, the electrical engineer usually employs one of several generally accepted methods.

He may follow the method described in "Alternating Currents and Alternating Current Machinery," by D. C. and J. P. Jackson. In this case, one of the phase voltages will be expressed as the sum of two unknown scalars in quadrature, viz. $e_1 = a + jb$ where $a$ and $b$ are the two unknowns. Since the line voltages are known, the remaining phase voltages may also be determined as functions of $a$ and $b$. Each phase current may then be expressed as the product of the phase voltage and its phase admittance. But since the neutral is not grounded, the sum of the phase currents must equal zero, so that by suitable factoring the following expression is obtained:

$$\Sigma i = f_1(a,b) + jf_2(a,b) = 0$$

or

$$f_1(a,b) = 0, \qquad f_2(a,b) = 0$$

The two simultaneous linear equations may then be solved for $a$ and $b$ in the conventional manner.

The advantage of this method is that it is methodical and easily adaptable to schedule form. Unfortunately, there are many opportunities for errors to occur because of the large number of operations. For example, the solution of a single phase voltage requires about 21 multiplications, 21 divisions, and 17 additions. This is a total of 55 operations, each of which could involve a mistake. Another disadvantage of this method is that since only scalar quantities are used, the advantages of the vector slide rule cannot be fully realized.

A method using vector quantities, and hence much more adaptable to the vector slide rule, is that described by Bryant, Correll, and Johnson in their "Alternating Current Circuits." Here, the vector residual is taken as the unknown. (The residual is the voltage difference between the common point and the true neutral.) As in the first method, expressions for the phase voltages and phase currents are first found. The sum of the phase currents is equated to zero and the resulting equation then solved for the residual. All other quantities are then obtained from this particular value of residual.

A general solution based on Kirchoff's law and employing conventional current-mesh equations also may be used as described in "Alternating Current Circuits" by M. P. Weinbach.

All these methods lack directness and brevity. A method which is both direct and excellently suited to the vector slide rule is described as follows:

Let the three lines be characterized by the numbers 1, 2, and 3. The line voltages are then $E_{1-2}$, $E_{2-3}$, $E_{3-1}$; the phase voltages are $e_1$, $e_2$, $e_3$; and the respective phase admittances are $Y_1$, $Y_2$, and $Y_3$. Using general numbers, the following equations may then be written,

$$\begin{aligned} E_{1-2} &= e_1 - e_2 \\ E_{2-3} &= e_2 - e_3 \\ E_{3-1} &= e_3 - e_1 \end{aligned} \tag{1}$$

Expressing all phase voltages in terms of $e_1$,

$$\begin{aligned} e_1 &= e_1 \\ e_2 &= e_1 - E_{1-2} \\ e_3 &= e_1 - E_{1-3} \end{aligned} \tag{2}$$

Also

$$\begin{aligned} i_1 &= e_1 Y_1 \\ i_2 &= (e_1 - E_{1-2}) Y_2 \\ i_3 &= (e_1 - E_{1-3}) Y_3 \end{aligned} \tag{3}$$

Since, by hypothesis, there is no neutral return,

$$i_1 + i_2 + i_3 = 0$$

Or

$$e_1 Y_1 + (e_1 - E_{1-2}) Y_2 + (e_1 - E_{1-3}) Y_3 = 0 \tag{4}$$

Solving for the phase voltage, $e_1$, and deriving expressions for $e_2$ and $e_3$ in a similar manner, the following equations result:

$$e_1 = \frac{E_{1-2} Y_2 + E_{1-3} Y_3}{Y_1 + Y_2 + Y_3} \tag{5}$$

$$e_2 = \frac{E_{2-1} Y_1 + E_{2-3} Y_3}{Y_1 + Y_2 + Y_3}$$

$$e_3 = \frac{E_{3-1} Y_1 + E_{3-2} Y_2}{Y_1 + Y_2 + Y_3}$$

Similarity to dyadic notation will be noted in the subscripts; the first subscript of each numerator voltage is the same as the phase voltage; the second subscript indicates the correct admittance multiplier. Therefore, the rule for obtaining each expression is: Compute each $Y$ by forming the reciprocal of the $Z$. Determine the line voltage from the phase in question to each of the remaining two phases. Multiply each of these two line voltages by their respective terminating phase admittances. The sum of these two products divided by the sum of the three phase admittances gives the phase voltage in question. Since all other unknowns may be obtained from $e_1$ in steps 2 and 3, only $e_1$ need be found. However, as a check, $e_2$ and $e_3$ may be found with but little additional computation.

It is of interest to note that this method gives one of the desired unknowns immediately, there being no necessity to find

first simultaneous linear equations, the residual, or the system's impedance matrix. Consequently, the method requires only about 28 operations (such as addition, subtraction, multiplication, division, or slide-rule settings), whereas the other methods given will require from 50 to 60 operations. Also, since the derivation is general with respect to them, the line voltages may be unbalanced. The first method becomes complicated when used on unbalanced voltages because of the irrational numbers involved. The second method described, likewise, is unsatisfactory, because the voltage residual for unbalanced line voltages has but little meaning and would be difficult to determine.

Therefore, the advantages of the method derived here may be enumerated as follows:

1. It is especially suited for computation on the vector slide rule.

2. It requires a minimum of operations, thus reducing the opportunity for mistakes to occur.

3. It may be used with unbalanced line voltages provided the equation $E_{1\cdot2}+E_{2\cdot3}+E_{3\cdot1}=0$ is satisfied.

4. The simple rule governing subscripts makes the equations extremely easy to remember.

W. H. HUGGINS (Enrolled Student)

(School of engineering, Oregon State College, Corvallis)

## Union Pacific's New Steam-Electric Locomotive

*To the Editor:*

In the article entitled "Union Pacific's New Steam-Electric Locomotive," appearing in the October issue of ELECTRICAL ENGINEERING, there are several statements from which it might be inferred that the steam-turbine-electric locomotive was an entirely new development in railroad engineering, reflecting much co-operative research and design in the U. S. A.

This will be, of course, true of the unit described but may be misleading as a general statement, for the steam-turbine-electric locomotive has long had the serious attention of designers and builders in other countries.

In 1921 Sir Vincent Raven, then chief mechanical engineer of the North Eastern Railway Company, built a locomotive of this type which was in use for a number of years, receiving modifications from time to time; it incorporated a water-tube boiler, Parsons turbine and generator, fan-cooled system of condensers, series-wound motors, etc.

Others have followed; notably on the Swedish State Railways, which have employed the Ljungstrom turbine as prime mover. They have been fully described in the English and European technical press, and their details and performances are, doubtless, known to American locomotive engineers. Economic results attained with their use on regular main-line operation, for various periods over the past 17 years, have not hitherto justified them as serious competitors to steam and Diesel-electric locomotives under European conditions.

It may well prove that the quite different conditions for which the Union Pacific locomotive has been designed are those in which the steam-turbine-electric locomotive will find its true field; nevertheless the writer views with some doubts the claims and expectations appearing in the article on behalf of this very modern traveling power station carrying one customer.

Its very high-speed turbine and gearing, and wealth of automatic and interlocking details on the steam-raising plant, to name but a few of its novel features, do represent an advance in the art; whether they can stand up to the exacting conditions imposed by regular railroad schedules and justify themselves economically can hardly be known for some years ahead. That is, of course, the reason for which this locomotive has been built; if in, say, the year 1942, or happily earlier, the Union Pacific places further orders for similar or better locomotives of this type, then its sponsors may well receive the congratulations of the railroad world.

The steam-electric locomotive is a lineal descendant of the gas-electric and Diesel-electric types, which owe much of their early development to work done in England on engines for tanks during the Great War. As far as the writer is aware the first gas-electric locomotive to appear in North America was that brought out by the Canadian Pacific in 1925, which made a return transcontinental journey in very remarkable time on its first appearance. It followed a successful English design, and some of its equipment, including the prime mover, was, I believe, made in Scotland.

T. ALAN ROSS (M'24)

(c/o Lloyd's Bank, Ltd., 6, Pall Mall, London)

# Library • • • •

OPERATED jointly by the AIEE and the other founder societies, the Engineering Societies Library, 29 West 39th Street, New York, N. Y., offers a wide variety of services to members all over the world. Information about these services may be obtained on inquiry to the director.

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

GRAPHIC PRESENTATION. By W. C. Brinton. New York, Brinton Associates, 1939. 512 pages, illustrated, 9½ by 6 inches, fabrikoid, $5.00. A brief encyclopedia of methods for representing facts graphically, which covers maps, geneological charts, statistical charts, etc. Each variety is represented by specimens, with explanations of their uses and interpretation. The use of color is covered. In addition practical advice is given on equipment and methods for making graphs and exhibits, on reproduction, and on the use of graphic material. Glossary.

SCIENCE AND MECHANISATION IN LAND WARFARE. By D. Portway. New York, Chemical Publishing Company, 1939. 158 pages, diagrams, charts, 9 by 6 inches, fabrikoid, $2.50. Intended for students in the Cambridge University Officers' Training Corps, this book supplies, in non-technical language, the principles and some of the details underlying the scientific side of modern warfare. The several chapters are devoted to a description of fundamental scientific principles, the importance of railways in war, the various aspects of mechanization, weather problems, chemical warfare, the work of the army engineer and the signal corps, the artillery survey, and some problems of personnel.

THE SENIORITY PRINCIPLE IN UNION-MANAGEMENT RELATIONS. By F. H. Harbison. Princeton, N. J., Industrial Relations Section of Princeton University, 1939. 39 pages, 10 by 7 inches, paper, $0.75. This study, based largely upon personal interviews with employers and labor leaders, is a digest of experience and opinion on selected aspects of the seniority problem as it applies to the relations of union and management in the mass-production industries. It summarizes the reasons for the demand for seniority rights in trade-union agreements, the degree to which seniority is modified by other factors, and the manner in which these modified rights are applied.

SOCIAL FUNCTION OF SCIENCE. By J. D. Bernal. New York, Macmillan Company, 1939, 482 pages, charts, tables, 9 by 6 inches, cloth, $3.50. Sketches briefly the historical development of science, and considers its present organization, pointing out reasons for the present confused and inefficient status of scientific research and showing the forces of prejudice which act in opposition to it. Suggests ways of reorganization with the object of increasing the benefits society can gain from scientific activity.

ENGINEERING MATERIALS. By A. H. White. New York and London, McGraw-Hill Book Company, 1939. 547 pages, illustrated, 9 by 6 inches, cloth, $4.50. The greater part of this book is devoted to the manufacture, heat-treatment, fabrication, and properties of iron, steel, and the non-ferrous metals, with consideration of the effect of methods of fabrication on the physical properties. Subsequent chapters present information on clay products, lime and cements, fuels, water and its industrial utilization, corrosion and protective coatings, and plastics. References accompany each chapter.

THE CONSTRUCTION OF NOMOGRAPHIC CHARTS. By F. T. Mavis. Scranton, Pa., International Textbook Company, 1939. 132 pages, diagrams, etc., 8½ by 5 inches, fabrikoid, $2.00. Provides a practical course for engineers and advanced undergraduate students, discussing the theory of logarithms, the slide rule, and functional co-ordinate papers. Many examples of nomogram construction are included.

HOUSING FOR THE MACHINE AGE. By C. A. Perry. New York, Russell Sage Foundation, 1939, 261 pages, illustrated, 9 by 6 inches, cloth, $2.50. Compares methods of construction of houses and of automobiles with a view toward mass production. The neighborhood unit is examined, and the results of practical experience are set forth, with particular attention to the matter of assembling large plots in metropolitan districts. The final chapter discusses the social significance of the unit.

BUSINESS CYCLES. Two volumes. By J. A. Schumpeter. New York and London, McGraw-Hill Book Company, 1939. 1095 pages, charts, 9 by 6 inches, cloth, $10.00. An analysis of the causes and the mechanism of business cycles is presented, with a detailed discussion of statistical and historical material covering the past 150 years. These materials are arranged to form a series of exercises in the diagnosis of business situations.

ELECTRICAL TRANSMISSION AND DISTRIBUTION OF POWER. By H. V. Carpenter. Pullman, Wash., Students' Book Store, 1939. 84 pages, mimeographed, diagrams, etc., 11 by 9 inches, cardboard, $2.00. Covers the physical properties of transmission lines, the regulation of both low- and high-voltage lines, materials for overhead lines, choice of voltage, and the mechanical features of power lines. New methods of predetermining corona losses and of plotting catenary relations are included.

MACRAE'S BLUE BOOK. 47th annual edition, 1939–40. New York, MacRae's Blue Book Company, 3616 pages, illustrated, 11 by 8 inches, cloth, $15.00. The forty-seventh annual issue, while subject to the customary revision of the information, follows the established pattern. It provides an index of manufacturers and wholesalers and their local distributors, with addresses; indexed classified list of manufacturers; directory of commercial bodies, banks, railroads, and warehouses in towns of 1000 or more population, and list of trade names.

MY 50 YEARS IN ENGINEERING. By E. A. Hitchcock and M. Weed, with introduction by C. F. Kettering. Caldwell, Idaho, Caxton Printers, Ltd., 1939, 222 pages, illustrated, 9½ by 6 inches, cloth, $3.00. The life, work, and reminiscences of an engineer and teacher, whose working life has spanned a period of extremely rapid development in technical lines, presented in autobiographical form. His activities included railroad, steam power plant, and electric power work, "human engineering," and teaching.

PATENT FUNDAMENTALS. By A. Schapp, Schapp and Cole, San Francisco, Calif.; New York, Industrial Press, 1939. 176 pages, diagrams, 9 by 5 inches, cloth, $2.00. A non-technical explanation of what constitutes true invention is given, with practical examples. Other topics covered include procedure in obtaining adequate patent protection, drafting of effective claims, making assignments, and issuing licenses. Essential facts about trademarks and copyrights are presented.

# Institute Activities

## National

### Columbia Scholarship in Electrical Engineering

The governing bodies of Columbia University annually place at the disposal of the AIEE a scholarship in the graduate course in electrical engineering at Columbia University's school of engineering. The scholarship pays the annual tuition of $380. Its renewal for the completion of the course is dependent upon the standard of work maintained by the holder.

The graduate course in electrical engineering at Columbia may be either elective, leading to the degree of master of science, or prescribed, leading to that of electrical engineer. Candidates for the scholarship must fulfill the regular admission requirements for the course chosen, details of which will be sent on request by the secretary of the University, or the national secretary of the AIEE. No special examination is required.

Applicants for the scholarship for the academic year 1940–41 should send their qualifications to the National Secretary, AIEE headquarters, before June 1, 1940. Letters should state the candidate's age, birthplace, education, pertinent activities such as athletics or self-help in college, and references, and should enclose a photograph. A committee composed of W. I. Slichter, chairman, Francis Blossom, and H. C. Carpenter will consider the applications and report their selection to the University. Other qualifications being equal, preference will be given to members of AIEE Student Branches.

### Winter Convention to Be Reported in March Issue

As this issue goes to press, the Institute's 1940 winter convention is under way at New York, with every evidence of continuing the successful record of winter conventions. Registration for the first two days totaled 1,178, compared with 1,159 for the first two days of the 1939 convention, 1,027 for 1938, and 827 for 1937.

On Wednesday evening, January 24, the Edison Medal was presented to Philip Torchio (A'95, F'12) and the Hoover Medal to Gano Dunn (A'91, F'12). Following the medal presentations, Doctor Enrico Fermi delivered a lecture on "Nuclear Disintegrations", the essential substance of which is published on pages 57–8 of this issue. The March issue will contain the full report of the convention.

### *Future AIEE Meetings*

**Summer Convention**
Swampscott, Mass., June 24–28, 1940

**Pacific Coast Convention**
Los Angeles, Calif., August 26–30, 1940

## District

### Executive Committee of District 6 Meets

Revision of the existing regulations for grading student papers presented for the District Branch paper prizes was recommended at the annual meeting of the North Central District (6) executive committee, held at Omaha, Nebr., December 2, 1939. With the present method of grading undergraduate papers in the same manner as papers for National prizes, the heavy weighting given the factors, "Value in Its Field" and "Value to Electrical Engineering" was regarded by the committee as tending to discourage student competition. The committee voted unanimously that the matter be taken up with the national secretary.

A. L. Turner, District vice-president, was selected to represent the District on the National nominating committee.

The District will support the efforts of the Denver Section to have the 1941 summer convention held in that city. The only District meetings to be held during 1940, it was decided, will be the annual executive committee meeting, and the annual Student Branch Conference, the latter to be held at Grand Forks, N. Dak., April 19–20, 1940.

Noting that several Branches had held meetings at which the Scott anniversary film was shown, the committee decided to remind other Branches of the film's availability. Membership activities, Section co-operation with local societies, and other matters of District business were also discussed.

## Section

### Charleston Section to Be Formed

Formation of a Charleston, W. Va., Section was authorized by the AIEE executive committee at its meeting on December 11, 1939 (*EE, Jan. 1940, p. 43*). The new Section, 68th to be formed, will have a territory of 23 counties in West Virginia.

*The following items are contributed by C. A. Faust, Mansfield, Ohio, for the Sections committee*

### Madison Section Organizes Rock River Valley Subsection

At the request of 14 AIEE members and 25 local members from Rockford, Ill., Freeport, Ill., and Beloit, Wis., the Madison, Wis., Section has established the Rock River Valley Subsection at Rockford to serve the members in this area. The formal proposal to organize the new division was made at the November 10 meeting. Official authorization was granted at the December 15 meeting, held at the Hotel Faust in Rockford.

To provide for the establishment and conduct of Subsections, section 12 was added to the bylaws of the Madison Section. It provides that:

> Subsections may be proposed by the executive committee or by 10 members and must be confirmed by a majority vote at the following Section meeting; Subsection meetings supplement regular Section meetings; meetings and programs are planned by Subsection officers, but finances are handled through the Section, which will pro-rate to Subsections not over 25 per cent of the annual Section income; Subsection chairmen are ex officio members of the Section executive committee; Subsection policies and expenditures are to be in accordance with AIEE requirements.

### "Electricity in War" Washington Section Theme

Instead of selecting a variety of widely divergent subjects for its technical sessions, the Washington Section chooses one theme for a fiscal year, using all the technical meetings to develop it completely. Recognizing that war is the subject of greatest interest to the world today, the technical sessions committee selected "Electricity in War" as the theme for 1939–40.

To carry out the theme, a series of three programs is being held: electricity in aviation, electricity in the navy, and electricity in the army. Each program is divided into three sessions: a lecture meeting, an inspection trip, and a discussion meeting. Informal speakers' dinners, attended by the Washington Section executive and technical sessions committees, are held prior to the lecture and discussion meetings. Refreshments are served after these meetings. The notices for the technical sessions are being printed with a distinctive color to differentiate them from the regular meeting notices.

The "electricity in aviation" program, held before Christmas, was very favorably received, 140 attending the lecture meeting, 175 the inspection trip, and 130 the discussion meeting.

At the lecture meeting three authorities

spoke on "Electric Power in Aircraft," "Analysis of Power Generation and Distribution Problems in Aircraft," and "Certain Features of Aircraft Radio-Communication Systems and Equipment." The inspection trip was made to the Bolling Air Field Station. The discussion meeting, under ten leaders, covered electric versus hydraulic and other power, main versus auxiliary engine generator drives, generator units, a-c and d-c power in aircraft, electrically operated aircraft ordnance equipment, electrical system design, military aircraft transmitters, aircraft radio receivers and direction finders, blind landing, and radio aircraft radio operation.

### More Sections Announce Season's Programs in Advance

In addition to the eight Sections named in the January issue which distribute programs for the season prior to the first meeting, three more Sections—Milwaukee, Houston, and Oklahoma City—complete their season's programs in time to give the details to the members early in December.

Milwaukee prints the full program on a 4-page 3- by 5 1/2-inch white folder and includes the names of all officers and committee members.

Houston prints its program on a letter-size sheet and suggests that it be placed "under the glass on your desk." This schedule of meetings is distributed with a news letter containing other information of interest.

Oklahoma City announced the details of the remaining five meetings of the season on the notice for its December meeting.

### St. Louis and Memphis Sections Award Attendance Prizes

To increase attendance at meetings and to provide a bit of entertainment in addition to the regular programs, some Sections of the Institute present a prize to a member at each meeting. St. Louis has had this custom for 10 or 12 years, and Memphis has used it for more than 4 years.

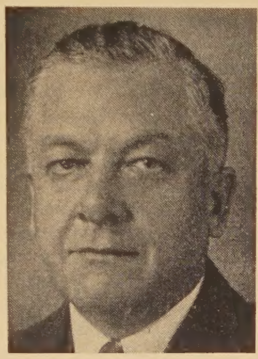
The St. Louis practice is to place membership cards in a box, have one drawn, and if the member whose name is drawn is present and wearing a badge with his name on it, he receives a prize. Prizes are usually electrical appliances donated by local dealers. The custom of wearing badges was adopted to help new members get acquainted, and is encouraged by the prize system.

Memphis has a $2 prize drawing at each monthly meeting. Five names are drawn, the fifth being the winner. If the winner is not present the prize is carried over and added to that for the next meeting. When the accumulated prize money reaches $10, names are drawn until one of the members present wins, and the prize for the next meeting is again $2. The amount of the prize is stated on meeting notices, and the Section secretary has noted that attendance increases with the prize.

**Holiday Activities.** An informal Christmas party was held by the North Texas Section for members and women guests on December 18, at the Baker Hotel, Dallas. Members of the St. Louis Section received a Christmas greeting on the gaily decorated notice for the December 13 meeting. The Denver Section sent greeting cards showing a mountain scene to Section members and nonmember friends of the Section.

# Personal . . .

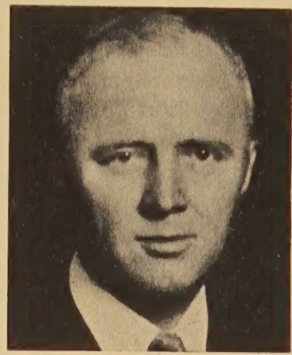
**F. M. Feiker** (M'34) executive secretary, American Engineering Council, has been appinted dean of the school of engineering, George Washington University, Washington, D. C. A native (1881) of Northampton, Mass., he received the degree of bachelor of science in electrical engineering in 1904 and the honorary degree of doctor of engineering in 1938 from Worcester Polytechnic Institute. After a year as research assistant at that institution, and two years of technical journalism with the General



F. M. FEIKER

Electric Company, Schenectady, N. Y., he became technical editor and later managing editor of *Factory*, and in 1912 chairman of the editorial board of A. W. Shaw Company, Chicago, Ill., publishers of *Factory* and *System* magazines and of technical books. He joined the McGraw-Hill Publishing Company, New York, N. Y., in 1915, as editor of *Electrical World*, eventually becoming vice-president and editorial director of the company. He was assistant to the United States secretary of commerce 1921–22, operating vice-president of the Society for Electrical Development, New York, 1922–26, and managing director, Associated Business Papers, New York, 1926–30. He then became director of the Bureau of Foreign and Domestic Commerce, Washington, D. C., and from 1932 to 1934 directed the educational survey of the Textile Foundation, Washington. Since 1934 he has been with AEC. He is also a member of The American Society of Mechanical Engineers.

**W. B. Kouwenhoven** (A'06, F'34) dean of engineering, Johns Hopkins University, Baltimore, Md., has been appointed chairman of the AIEE Lamme Medal committee, succeeding E. W. Allen, who died January 1, 1940. He has been a member of th committee since 1938. Doctor Kouwenhoven holds the degrees of electrical engineer (1906) and mechanical engineer (1907) from the Polytechnic Institute of Brooklyn, and a diploma in engineering (1913) and the degree of doctor of engineering (1914)



W. B. KOUWENHOVEN

from Karlsruhe Technische Hochschule, Baden, Germany. He was assistant in physics 1906–07 and instructor in physics and electrical engineering 1907–10 at Brooklyn Polytechnic Institute, and instructor in electrical engineering 1913–14 at Washington University, St. Louis, Mo. He joined the electrical-engineering department of Johns Hopkins University in 1914 as an instructor, becoming associate in 1917. After a leave of absence in 1919–20 as engineering superintendent of the Winchester Repeating Arms Company, New Haven, Conn., he returned to Johns Hopkins as associate professor of electrical engineering, becoming professor and assistant dean of the school of engineering in 1930, and dean in 1938. He has served the Institute as a vice-president (1931–33), director (1935–39), member of the committees on telegraphy and telephony, electrophysics, Sections (chairman 1927–30), co-ordination of Institute activities, technical program, and award of Institute prizes, and is currently a Student Branch counselor, and member of the Edison Medal committee, and the committees on safety, electrochemistry and electrometallurgy, instruments and measurements (chairman 1933–36), and research (chairman 1936–38).

**W. S. Conlon** (A'20, M'28) has resigned as executive secretary of the National Society of Professional Engineers, Washington, D. C. and opened his own office as consulting engineer in that city. He is one of the founders of the society and was its first treasurer, 1934–35, and since 1935 has been executive secretary in charge of its Washington office. Before going with the NSPE he was city engineer, City of Stamford, Conn.

**Tomlinson Fort** (A'27, M'35) has been made assistant manager of central-station sales, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. He has been with the company since 1923, when he entered the student course, and since 1931 had been engaged in central-station work at New York, N. Y., where he was active in affairs of the AIEE New York Section.

**G. M. Miller** (A'21, M'26) formerly superintendent of electrical distribution and construction, Louisville Gas and Electric Company, Louisville, Ky., has been appointed electrical engineer of the company. **J. F. Miller** (A'31,M'38) formerly assistant superintendent of electric distribution, has been made superintendent, and **V. L. McKinley** (A'27, M'34) formerly meter engineer, has been made assistant superintendent. Other changes in the company are transfers from the electrical-distribution department of **H. L. Lowe** (A'30, M'38) to the position of engineer in the electrical engineer's office, and of **F. W. Russell** (A'26) to the position of engineer in the general superintendent's office; promotion of **M. S. Winstandley** (A'29) to the position of electrical construction engineer; and appointment of **C. M. Ewing** (A'26) as assistant superintendent of electrical production.

**R. A. Jones** (A'20, M'39) has been appointed district engineer, New York district, General Electric Company. He has been with the company since 1916, when he entered the test course at Schenectady, and since 1938 had been assistant district engineer at New York, N. Y. He is succeeded in that position by **W. S. Hill** (A'25, M'30), who has been with General Electric since entering the test course in 1923.

**D. D. Knowles** (M'39) since 1937 director of research and development, Raytheon Production Corporation, Newton, Mass., has joined the research engineering staff of the special products department of Westinghouse Lamp Division, Bloomfield, N. J. He was formerly associated with the Westinghouse company at East Pittsburgh, Pa., from 1923 to 1937.

**R. D. Mailey** (F'30) formerly vice-president-General Electric Vapor Lamp Company, Hoboken, N. J., until the merger with the company's incandescent lamp department at Cleveland, Ohio, has been transferred to the lamp development laboratory at Cleveland to supervise various phases of development of gaseous-discharge lamps.

**H. S. Osborne** (A'10, F'21) operating results engineer, American Telephone and Telegraph Company, New York, N. Y., has been elected vice-chairman of the Standards Council of the American Standards Association. An Institute director and finance-committee chairman, he is one of three AIEE representatives on the Council.

**A. L. O'Bannion** (A'21, M'28) formerly electrical engineer of the Sumner traffic tunnel at Boston, Mass., has been made superintendent of the fire-alarm division of the Boston Fire Department. His previous experience includes both industrial and teaching positions.

**H. E. Smith** (A'25) formerly supervising design engineer, Commonwealth Edison Company, Chicago, Ill., has been made line design engineer. He has been with the company since 1917, except for military service.

**R. K. Hellman** (A'37) formerly with Transatlantic Research and Information Service, Inc., New York, N. Y., is now an electrical engineer for Connecticut Telephone and Electric Corporation, Meriden, Conn.

**W. A. Buchanan** (M'36) formerly plant wire chief, Chesapeake and Potomac Telephone Company of West Virginia, Charleston, has been appointed district plant manager at Charleston.

**F. A. Kartak** (A'10, F'33) dean of engineering, Marquette University, Milwaukee, Wis., has been elected president of the Engineers' Society of Milwaukee.

# Obituary • • •

**Henry Latham Doherty** (A'98, M'02, F'13) president and founder, Cities Service Company, died December 27, 1939, at Temple University Hospital, Philadelphia, Pa. He was born May 15, 1870, in Boone County, Ind. He never received a formal technical education, but was awarded the honorary degrees of doctor of engineering from Lehigh University, doctor of laws from Temple University, and doctor of science from the University of Miami. At the age of 12 he became an office boy for the Columbus, Ohio, Gas Company, and advanced through various positions to become assistant general manager of that company. In 1896 he became general manager and engineer of the Madison (Wis.) Gas and Electric Company. During the period 1898–1904 he was chief engineer for various properties of the McMillin interests, in St. Paul, Minn., San Antonio, Tex., and Denver, Colo. In 1905 he organized Henry L. Doherty and Company, bankers and operators of public utilities, and in 1910 founded the Cities Service Company, parent of nearly 200 oil, traction, light, gas, and power subsidiaries throughout the United States. He received the first Beill Gold Medal of the American Gas Light Association in 1898; was a member of the organization board of the World's Congress of Electricity, St. Louis, Mo., 1904; and in 1930 was awarded the Walton Clark Medal of the Franklin Institute for his work in the development of the manufactured gas industry. In 1937 he was awarded the Anthony F. Lucas Medal of the American Institute of Mining and Metallurgical Engineers for his contributions to the petroleum industry, notably his discovery of the relation of natural gas to oil production and his pioneer advocacy of the "unit plan" of developing oil pools. He was active in the foundation of the American Petroleum Institute and long a member of its board of directors. Among his other interests was real-estate development in New York City and in Florida. He was a director of many corporations, held more than 150 patents, and was a past president of the Northwestern Electric Association, National Electric Light Association, and Ohio Gas Light Association, and also member of the American Association for the Advancement of Science, American Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Heating and Ventilating Engineers, Franklin Institute, and other societies.

**Edwin Wood Allen** (A'03, F'22) vice-president, General Electric Company, Schenectady, N. Y., died January 1, 1940, at Johns Hopkins Hospital, Baltimore, Md. He was born at Buchanan, Va., November 9, 1879, and received the degree of bachelor of science in electrical engineering from Virginia Polytechnic Institute in 1900. The following year he entered the employ of General Electric as a student engineer at Schenectady and except for military service 1917–19 was with the company continuously until his death. He was appointed engineer of the central district in 1911 with headquarters at Chicago, Ill., in 1913 was given the additional duties of assistant manager of the district, and in 1924 became manager of the engineering department at Schenectady. He became a vice-president in 1926. During the World War he served in France as a major in the United States Army, and after the armistice went to Brussels for the War Damage Board of the Peace Commission. He had been Institute representative on the United States national committee of the International Electrotechnical Commission, and a member of the education and Lamme Medal committees, and was chairman of the latter committee at the time of his death. He was also a member of the Western Society of Engineers.

**James Harvey Gravell** (A'17) president, American Chemical Paint Company, Ambler, Pa., died recently, according to information just received at Institute headquarters. He was born October 12, 1880, at Philadelphia, Pa., and educated there. In 1898 he was employed by the Electrical Storage Battery Company, Philadelphia, as assistant in the electrical laboratory, and the following year went with the Ellwood Irvin Tube Works, Philadelphia, to experiment with electrical welding. In 1901 he was employed by the American Tube and Stamping Company, Bridgeport, Conn., and continued work with welding there, and later at the Baldwin Locomotive Works and in a business of which he was a partner. In 1905 he became engineer and sales agent for the Synnestvedt Automobile Company, Pittsburgh, Pa.; in 1907 assistant electrical engineer, Dodge and Day Company, Philadelphia; in 1908, laboratory assistant on special tests, Philadelphia Electric Company; in 1910 engineer in charge of electric welding, Hale and Kilburn Company, Philadelphia. In 1914 he was associated with the formation of the American Chemical Paint Company, becoming secretary-treasurer and consulting engineer. Some years later he became president of the company. He was also consulting engineer for a number of other companies, being especially concerned with welding and patents.

**Stefaan Piek** (A'06) retired vice-president, Niagara Hudson Power Corporation, died at Syracuse, N. Y., December 13, 1939. He

was born in The Netherlands, June 26, 1876, and was graduated as a mechanical engineer at Delft, Netherlands, in 1899 and as an electrical engineer at Zurich, Switzerland, in 1901. In the latter year he became a draftsman for Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., and was later employed by the Lackawanna Steel Company, Buffalo, N. Y., and by the Fulton Bag and Cotton Works, Atlanta, Ga. In 1904 he became electrical foreman of the Niagara Construction Company, Niagara Falls, Ont., Can., later becoming assistant engineer for the Iroquois Construction Company, and electrical engineer for the Ontario Power Company. Subsequently he became superintendent of the Niagara, Lockport, and Ontario Power Company, and later assistant general manager, general manager, and vice-president. In 1929 he was made a vice-president of the Niagara Hudson Power Corporation, and executive vice-president of the Syracuse Lighting Corporation, which was later absorbed into the Central New York Power Corporation. He retired in 1938.

**Alma Preston Sessions** (M'37) substation engineer, Southern California Edison Company, Ltd., Los Angeles, Calif., died recently, according to information just received at Institute headquarters. He was born April 29, 1893, at Santa Monica, Calif., and received the degree of bachelor of science in electrical engineering from the University of Arizona in 1916. During the next two years he was an instructor in science and mathematics, Gila Academy, Thatcher, Ariz., and during part of 1918 was in charge of electrical testing for the Detroit Copper Company, Morenci, Ariz. He was engaged in the design and installation of generating plants, water supply system, and other equipment at the Arizona State Industrial School, Fort Grant, from 1918 to 1922, except for short periods of testing work for the Western Machinery Diesel engine factory, Los Angeles, Calif., and the Roosevelt Power System, Phoenix, Ariz. He went to the Southern California Edison Company in 1923 as construction foreman on the Laguna Bell substation, later being transferred to the operating department. He became engineer of substations in 1926.

**Omenzo George Dodge** (A'93, M'95) retired commodore, United States Navy, Washington, D. C., died in June 1936, according to information just received at Institute headquarters. He was born in Mendon, Mich., June 1, 1856, and was graduated in 1877 from the United States Naval Academy. In 1880 he became an ensign and in 1887 a lieutenant in the Navy. In addition to regular duties, he served 18 months at the Smithsonian Institution, 6 months on the United States Geological Survey, and 2½ years on the United States Coast Survey. For 4 years he was an instructor in physics and chemistry at the Naval Academy, Annapolis, Md. He had various duties in the Navy as an electrical engineer, and in 1892 resigned his lieutenant's commission to become professor of mathematics, United States Navy. He attained the rank of commander in the Navy in 1899, that of captain in 1908, and subsequently reached that of commodore.

**Harry Wheelock Mowry** (A'18, M'29) office manager, general installation organization, Western Electric Company, New York, N. Y., died December 10, 1939, at South Orange, N. J. He was born in Cerro Gordo County, Iowa, September 12, 1881, and received the degree of bachelor of science in electrical engineering from the University of Minnesota in 1906. After a few months with the Kellogg Switchboard and Supply Company, Chicago, he joined the equipment engineering department of Western Electric at Chicago. He was placed in charge of central-office engineering at Chicago in 1917. In 1920 he became the company's resident engineer at the Automatic Electric Company's plant at Chicago, and in 1923 was appointed installation-development engineer at New York.

**Harry Randall Allensworth** (A'04, M'13) consulting engineer, Columbus, Ohio, died November 29, 1939. He was born January 21, 1880, at Columbus, and educated there, and through correspondence courses in technical subjects. He was employed as a telegraph operator and a wireman before becoming electrician for the City of Columbus in 1902, in which position he continued until 1914. He was valuation engineer for the Ohio State Telephone Company 1914–17, and for the Tri-State Telephone and Telegraph Company 1917–23. In 1923 he entered private practice as a consulting engineer, specializing in public-utility economics. He was also a member of the Western Society of Engineers.

**Walter C. Nielsen** (A'37) tester, Consolidated Edison Company of New York, Inc., New York, N. Y., died October 4, 1939, according to information recently received. He was born at New York, April 29, 1907, and received the degree of bachelor of science in electrical engineering at New York University in 1936. Since 1926 he had been employed in the test bureau of the New York Edison Company and its successor Consolidated Edison.

# Membership

## Recommended for Transfer

The board of examiners, at its meeting on January 18, 1940, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

### To Grade of Fellow

Brenton, Walter, chief engineer, Portland General Electric Company, Portland, Ore.
Nathan, E. J., engineer, The Bell Telephone Company of Pennsylvania, Philadelphia.
Work, W. R., head, department of electrical engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

3 to Grade of Fellow

### To Grade of Member

Jahn, Emil, electrical design engineer, J. G. White Engineering Corporation, New York, N. Y.
Macfarlane, G. O., manager, General Electric Company, Memphis, Tenn.
Patterson, H. M., electrical engineer, Copper Wire Engineering Association, Washington D. C.
Strong, E. M., assistant professor of electrical engineering, Cornell University, Ithaca, N. Y.

4 to Grade of Member

## Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical Districts. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before February 29, 1940, or April 30, 1940, if the applicant resides outside of the United States or Canada.

### United States and Canada

1. North Eastern

Ahern, W. R., New England Power Company, Quincy, Mass.
Bokan, J. J., General Electric Company, Schenectady, N. Y.
Boyer, R. P., Jr., 125 Franklin Street, Newton, Mass.
Buckley, T. F., Central New York Power Corporation, Syracuse, N. Y.
Cepelak, J., Jr., Scovill Manufacturing Company, Waterbury, Conn.
Dimock, W. B., Stamford Gas and Electric Company, Stamford, Conn.
Dutton, J. C., General Electric Company, Pittsfield, Mass.
Franklin, J. S., General Electric Company, West Lynn, Mass.
Gauss, F. S., Palmer Electric and Manufacturing Company, Wakefield, Mass.
Hoare, D. L., The Southern New England Telephone Company, New Haven, Conn.
Hughson, J. D., General Railway Signal Company, Rochester, N. Y.
James, A. A., Southern New England Telephone Company, New Haven, Conn.
McCurry, E. T., General Electric Company, Pittsfield, Mass.
Mikelson, W., General Electric Company, Schenectady, N. Y.
Packard, L. E., General Radio Company, Cambridge, Mass.
Rissberger, A. C., Jr., 160 Rugby Avenue, Rochester, N. Y.
Rosenthal, I., Club Photo Service, Boston, Mass.
Rouault, C. L., General Electric Company, Lynn, Mass.
Segerstrom, C. A., Jr., Hygrade Sylvania Corporation, Salem, Mass.
Smith, R. J. (Member), Palmer Electric and Manufacturing Company, Wakefield, Mass.
Sprague, R. C. (Member), Sprague Specialties Company, North Adams, Mass.
Sweeny, J. O., General Electric Company, Pittsfield, Mass.
Williams, C. A. (Member), The United Illuminating Company, New Haven, Conn.

2. Middle Eastern

Adolphe, M. H., Owens-Corning Fiberglas Corporation, Newark, Ohio.
Armor, M. K., Rural Electrification Administration, Washington, D. C.
Ball, H. E., Cutler Hammer, Inc., Cleveland, Ohio.
Barkle, J. E., Jr., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Barr, T. L., Federal Works Agency, Washington, D. C.
Beckett, J. C., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Black, C. F., Republic Steel Corporation, Cleveland, Ohio.
Boone, E. M., Ohio State University, Columbus.
Cachat, J. F., Cleveland Electric Illuminating Company, Cleveland, Ohio.
Clark, J. J., Jr., Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.
Costrell, L., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Crummitt, C. B., Chesapeake and Potomac Telephone Company, Washington, D. C.
Cushing, G. B., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Dornbush, H. W., Pennsylvania Transformer Company, Pittsburgh.
Edwards, P. J., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Eisen, N., Westinghouse Electric and Manufacturing Company, Philadelphia, Pa.
Ellis, W. R., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Eyman, D. H., Westinghouse Electric and Manufacturing Company, Sharon, Pa.

Fallon, G. P. (Member), Consolidated Gas, Electric Light and Power Company of Baltimore, Baltimore, Md.
Ford, J. H., Allis-Chalmers Manufacturing Company, Washington, D. C.
Gall, C. R., B. A. Wesche Electric Company, Cincinnati, Ohio.
Gehrung, J. H., Republic Steel Corporation, Cleveland, Ohio.
Gray, F. C. (Member), Copper Wire Engineering Association, Washington, D. C.
Holland, C. W., Jr , American Car and Foundry Company, Berwick, Pa.
Hopkins, R. B., General Electric Company, Philadelphia, Pa.
Howard, L. E., General Electric Company, Philadelphia, Pa.
Jensen, I., Pusey and Jones Corporation, Wilmington, Del.
Johnstone, B. B., Rural Electrification Administration, Washington, D. C.
Kandoian, A. G., International Telephone Development Company, Newark, N. J.
Kussmaul, E. E., Public Service Electric and Gas Company, Newark, N. J.
Leet, C. H., Electric Storage Battery Company, Pittsburgh, Pa.
Manwaring, A. H., II (Member), Philadelphia Electrical and Manufacturing Company, Philadelphia, Pa.
McKay, J. L. (Member), Bell Telephone Company of Pennsylvania, Philadelphia.
Mikos, J. J., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Mills, R. W., Cleveland Electric Illuminating Company, Cleveland, Ohio.
Nau, R. H., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Nooe, H. R., Jr., Rural Electrification Administration, Washington, D. C.
Nopper, E. J., Sun Oil Company, Philadelphia, Pa.
O'Conor, J. J., Consolidated Gas, Electric Light and Power Company, Baltimore, Md.
Pollard, C. L., Pennsylvania Power and Light Company, Danville.
Ray, J. J., Philadelphia Electric Company, Philadelphia, Pa.
Riley, J. J., Delco Products, Dayton, Ohio.
Sauerwein, G. F., Jr., Westinghouse Lamp Company, Trenton, N. J.
Smith, S. S., Jr., Duquesne Light Company, Pittsburgh, Pa.
Smith, W. T., Rural Electrification Administration, Washington, D. C.
Snedeker, M. L., United Broadcasting Company, Cleveland, Ohio.
Sparrow, W. G., Bell Telephone Company of Pennsylvania, Sharon.
Stage, H. C., Carlton Lamp Corporation, Union City, N. J.
Taylor, G. H., Eclipse Aviation Company, Bendix, N. J.
Toshniwal, B. D., RCA Manufacturing Company, Inc., Camden, N. J.
Walz, H. G., Public Service Electric and Gas Company, Jersey City, N. J.
Wilkinson, R. W., Bell Telephone Company of Pennsylvania, Philadelphia.
Yevick, J. G., Potomac Electric Power Company, Washington, D. C.
Zehfuss, E. A. (Member), Duquesne Light Company, Pittsburgh, Pa.

3. New York City

Bernius, W. K., Sperry Gyroscope Company, Brooklyn, N. Y.
Boyd, J. (Member), Westinghouse Electric and Manufacturing Company, New York, N. Y.
Clasen, A. J., American Bank Note Company, New York, N. Y.
Del Papa, F., National Sugar Refining Company, Long Island City, N. Y.
Ferguson, J. R. (Member), New York Telephone Company, New York, N. Y.
Fickinger, C. H., New York Telephone Company, New York, N. Y.
Finch, T. R., Bell Telephone Laboratories, Inc., New York, N. Y.
Fulton, R. A., Jr., Cheney and Foster, New York, N. Y.
Gardner, M. L., Westinghouse Electric and Manufacturing Company, New York, N. Y.
Hammel, A. P. (Member), New York Telephone Company, New York, N. Y.
Hilbert, E. A., Consolidated Edison Company of New York, Inc., New York, N. Y.
Hodges, E. P., New York Telephone Company, New York, N. Y.
Hooker, H. H., Underwriters' Laboratories, Inc., New York, N. Y.
Johnson, L. W. (Member), c/o Robert Goelet, New York, N. Y.
Kerner, J. R., Westinghouse Electric and Manufacturing Company, New York, N. Y.
Koliss, P. P., Bell Telephone Laboratories, Inc., New York, N. Y.
Noller, W. E., Bell Telephone Laboratories, Inc., New York, N. Y.
Reveal, P. A., WOR and The Mutual Broadcasting System, New York, N. Y.
Robisch, I. C., Consolidated Edison Company of New York, Inc., New York, N. Y.
Samoos, W. J., Stanroy Management Corporation, New York, N. Y.
Smith, H. M., Columbia University, New York, N. Y.
Smoot, A. W., Underwriters' Laboratories, Inc., New York, N. Y.
Tannenbaum, A. (Member), Consolidated Edison Company of New York, Inc., New York, N. Y.
Van Nort, L. N., New York Telephone Company, New York, N. Y.
Verdi, J. J., Brooklyn Edison Company, Inc., Brooklyn, N. Y.
Volp, L. J., Consolidated Edison Company of New York, Inc., New York, N. Y.
von der Horst, W., Jr., Aetna Insurance Company, New York, N. Y.

4. Southern

Bostwick W. M., Florida Power and Light Company, Daytona Beach.
Flynt, E. R., Alabama Power Company, Huntsville.
Harry, H. E., War Department, Second District, New Orleans, La.
Horney, H. W., Carolina Aluminum Company, Badin, N. C.
Hutchison, C. E., Westinghouse Electric and Manufacturing Company, Memphis, Tenn.
Kanning, R. H., Alabama Power Company, Mobile.
Kraybill, E. K., Duke University, Durham, N. C.
Levkoff, M., 521 Santee Avenue, Columbia, S. C.
Lewis, C. P., Sandlick Coal Company, Whitesburg, Ky.
Markham, R. T., Gibson County Membership Corporation, Trenton, Tenn.
Ray, C. A., Southern Bell Telephone and Telegraph Company, Knoxville, Tenn.
Reed, C. E., Lyman C. Reed, New Orleans, La.
Scott, M. F. (Member) Alabama Power Company, Birmingham.
Tatum, G. M., Virginia Public Service Company, Charlottesville.
Walker, C. S., University of Alabama, University, Ala.
Woolfolk, J. K. (Member), State Corporation Commission of Virginia, Richmond.

5. Great Lakes

Anderson, R. L., American Gas and Electric Service Corporation, Muncie, Ind.
Beattie, C. S. (Member), Delta-Star Electric Company, Chicago, Ill.
Boeker, H. T., General Electric X-ray Corporation, Chicago, Ill.
Cragg, R. E., Commonwealth Edison Company, Chicago, Ill.
Dollenmaier, J. M., Line Material Company, Detroit, Mich.
Ewy, A., Milwaukee, Wis.
Feldhausen, C. P. (Member), Cutler Hammer, Inc., Milwaukee, Wis.
Gregory, J., Guardian Electric Manufacturing Company, Chicago, Ill.
Guldi, W. E., Carnegie-Illinois Steel Corporation, Gary, Ind.
Hansen, K. H., Cutler Hammer, Inc., Milwaukee, Wis.
Hausske, G. A. (Member), Pure Oil Company, Chicago, Ill.
Jones, E. E., Iowa State College, Ames.
Karle, R. D., American Telephone and Telegraph Company, Chicago, Ill.
Koehler, A. A., Public Service Company of Indiana, Indianapolis.
Kryder, P. A., Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
Ku, T. H., 471 North Grant Street, West Lafayette, Ind.
Lee, S., 208 South Street, West Lafayette, Ind.
Lyon, W. D., Illinois Bell Telephone Company, Chicago.
Marcus, J. L., American Electric Company, Indianapolis, Ind.
May, R. F., University of Michigan, Ann Arbor.
Michaels, H. J., Allis-Chalmers Manufacturing Company, West Allis, Wis.
Mikolic, C. R., Allis-Chalmers Manufacturing Company, West Allis, Wis.
Miller, R. E., Allis-Chalmers Manufacturing Company, Milwaukee, Wis.
Mirick, R. B., Pillsbury Flour Mills Company, Minneapolis, Minn.
Polakowski, E. J., Cutler Hammer Inc., Milwaukee, Wis.
Rosch, J. M., Commonwealth Edison Company, Chicago, Ill.
Ruth, J. A., University of Michigan, Ann Arbor.
Saunders, R. M., University of Minnesota, Minneapolis.
Schaefer, M. W., Allis-Chalmers Manufacturing Company, West Allis, Wis.
Senn, J. A., Cutler Hammer Inc., Milwaukee, Wis.
Snyder, V. J., General Electric Company, Detroit, Mich.
Sorflaten, C. G., Commonwealth Edison Company, Chicago, Ill.
Thomas, H. A., Purdue University, West Lafayette, Ind.
Thomen, M. K., Jr., General Electric Company, Fort Wayne, Ind.
Yonkers, E. H., Joslyn Manufacturing and Supply Company, Chicago, Ill.

6. North Central

Mueller, J. W., Nebraska Power Company, Omaha, Nebr.
Pirtle, P. E., Box 744, Green River, Wyo.
Steen, W. J., Nebraska Power Company, Omaha.
Weers, A. F., Rocky Mountain Engineering Company, Denver, Colo.

7. South West

Brinker, C. S., Westinghouse Electric and Manufacturing Company, St. Louis, Mo.
Burns, C. H., Phillips Petroleum Company, Bartlesville, Okla.
Davis, S. W. (Member), Southwestern Public Service Company, Amarillo, Tex.
Eshelman, H. K., Kansas Power Company, Liberal.
Francis, M. C., Southwestern Bell Telephone Company, Kansas City, Mo.
McReynolds, J. M., Houston Lighting and Power Company, Houston, Tex.
Morris, W. C., Jr., Southwestern Gas and Electric Company, Overton, Tex.
Petzing, W. N., General Electric Company, Dallas, Tex.
Philpott, C. G., Missouri Power and Light Company, Jefferson City.
Price, J. T., Southwestern Public Service Company, Amarillo, Tex.
Rivoire, O. G., Dallas Power and Light Company, Dallas, Tex.
Robson, R., Union Electric Company of Missouri, Webster Groves.
Seewald, L., Southwestern Public Service Company, Amarillo, Tex.
Setzer, L. E., Huzzak Route, Box 15, Steelville, Mo.
Skinner, R. S., Southwestern Bell Telephone Company, Kansas City, Mo.
Tosch, R. L., Dallas Power and Light Company, Dallas, Tex.
Totten, R. E., Clifton, Kans.
White, H. A., General Electric Company, Dallas, Tex.
Wightman, F. N., Westinghouse Electric and Manufacturing Company, St. Louis, Mo.
Wills, E. E., Westinghouse Electric and Manufacturing Company, St. Louis, Mo.
Wood, F. P., Dallas Power and Light Company Dallas, Tex.
Woods, H. S., General Electric Company, Kansas City, Mo.

8. Pacific

Cummings, C. C., Bank of America, San Diego, Calif.
English, A. M., 462 Stow Avenue, Oakland, Calif.
Glavinovich, L. V., Pacific Gas and Electric Company, San Francisco, Calif.
Gould, E. H., Jr. (Member), 927½ Carolina Street, Vallejo, Calif.
Gow, K. P., U. S. Soil Conservation Service, Los Angeles, Calif.
Lipow, J. H., 2908 West Vernon Avenue, Los Angeles, Calif.
Matthew, T., Southern California Edison Company, Santa Monica, Calif.
Sumerlin, W. T., Hollywood Transformer Company, Hollywood, Calif.
Thompson, J. L. (Member), Kelman Electric and Manufacturing Company, Los Angeles, Calif.
Troost, T. W. (Member), Imperial Irrigation District, Imperial, Calif.
Von Bergen, C. A., Pacific Gas and Electric Company, Oakland, Calif.
Whitney, G. W., Simmons Company, San Francisco, Calif.
Wynn, H. L., Pacific Electrical Manufacturing Corporation, San Francisco, Calif.

9. North West

Bailey, B. M., Pacific Power and Light Company, Portland, Ore.
Embry, A. L., Board of Fire Underwriters of the Pacific, Salt Lake City, Utah.
Gibney, E. L. (Member), City of Seattle, Seattle, Wash.
Martin, E. E., W. S. McCrea, Jr., and R. M. Towne, Engineers, Tacoma, Wash.
Schneider, H. R., Montana Power Company, Great Falls.
Swanson, L. W., United States Engineers, Portland, Ore.
Treffinger, F. M., Puget Sound Power and Light Company, Seattle, Wash.
Walker, R. K., University of Washington, Seattle.
Washburn, C. A., Utah Power and Light Company, Grace, Idaho.

10. Canada

Ackhurst, W. H., Canadian General Electric Company, Ltd., Peterboro, Ont.
Findlay, S. M., Station CFGP, Grande Prairie, Alberta.
Larsen, M. P., British Columbia Underwriters Association, Vancouver.
Moull, W. C., Canadian General Electric Company, Ltd., Peterboro, Ont.

Total, United States and Canada, 207

Elsewhere

Bourlon, A., Hubard and Bourlon Sucrs., Mexico, D. F., Mexico.
Havinga, M. J. S., c/o Municipality, Wolmaransstad, Transvaal, South Africa.
Lewis, D. G., Cia de Electricidad del Sud Argentino, Buenos Aires, Argentine, S. A.
Shah, S. M. H., Shkoor Ali and Sons, Simla, Punjab, India.

Total elsewhere, 4